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MINERAL COMMODITY SUMMARIES 1988

BUREAU OF MINES
(With resource information by the GEOLOGICAL SURVEY)
UNITED STATES DEPARTMENT OF THE INTERIOR

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MINERAL
COMMODITY SUMMARIES

1988

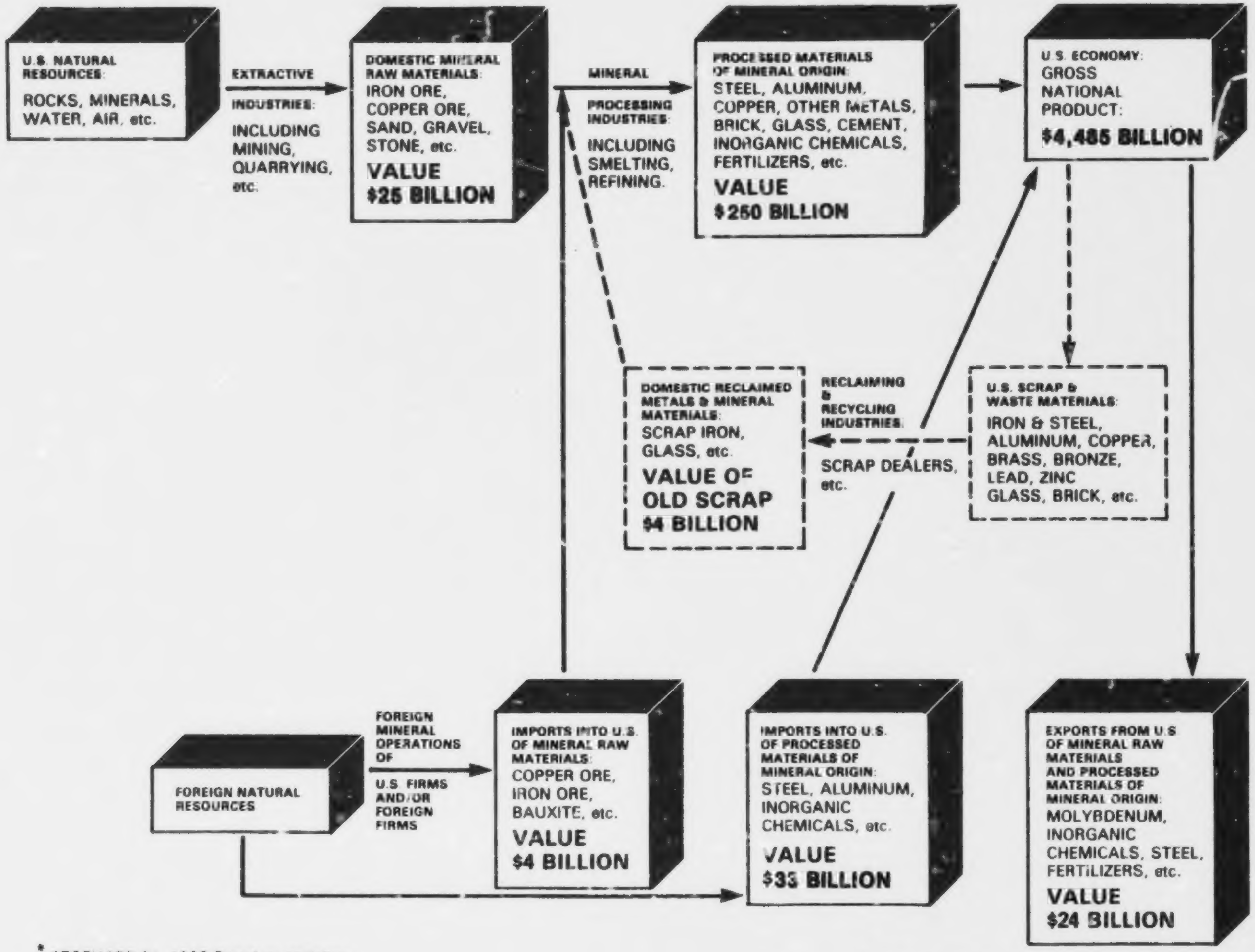
AN UP-TO-DATE SUMMARY OF 87
NONFUEL MINERAL COMMODITIES

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

This report is the earliest Government publication to furnish estimates covering 1987 nonfuel mineral industry data. Most of the estimates are based on 9 months data. These data sheets contain information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for 87 individual minerals and metals. World resource data appearing in the statements have been provided by the Geological Survey.

THE ROLE OF NONFUEL MINERALS IN THE U.S. ECONOMY

(ESTIMATED VALUES FOR 1987) *



U.S. NATURAL RESOURCES:
ROCKS, MINERALS, WATER, AIR, etc.

EXTRACTIVE INDUSTRIES:
INCLUDING MINING, QUARRYING, etc.

DOMESTIC MINERAL RAW MATERIALS:
IRON ORE, COPPER ORE, SAND, GRAVEL, STONE, etc.
VALUE
$25 BILLION

MINERAL PROCESSING INDUSTRIES:
INCLUDING SMELTING, REFINING.

PROCESSED MATERIALS OF MINERAL ORIGIN:
STEEL, ALUMINUM, COPPER, OTHER METALS, BRICK, GLASS, CEMENT, INORGANIC CHEMICALS, FERTILIZERS, etc.
VALUE
$250 BILLION

U.S. ECONOMY:
GROSS NATIONAL PRODUCT:
$4,485 BILLION

U.S. SCRAP & WASTE MATERIALS:
IRON & STEEL, ALUMINUM, COPPER, BRASS, BRONZE, LEAD, ZINC GLASS, BRICK, etc.

RECLAIMING & RECYCLING INDUSTRIES:
SCRAP DEALERS, etc.

DOMESTIC RECLAIMED METALS & MINERAL MATERIALS:
SCRAP IRON, GLASS, etc.
VALUE OF OLD SCRAP
$4 BILLION

FOREIGN NATURAL RESOURCES

FOREIGN MINERAL OPERATIONS OF
U.S. FIRMS AND/OR FOREIGN FIRMS

IMPORTS INTO U.S. OF MINERAL RAW MATERIALS:
COPPER ORE, IRON ORE, BAUXITE, etc.
VALUE
$4 BILLION

IMPORTS INTO U.S. OF PROCESSED MATERIALS OF MINERAL ORIGIN:
STEEL, ALUMINUM, INORGANIC CHEMICALS, etc.
VALUE
$33 BILLION

EXPORTS FROM U.S. OF MINERAL RAW MATERIALS AND PROCESSED MATERIALS OF MINERAL ORIGIN:
MOLYBDENUM, INORGANIC CHEMICALS, STEEL, FERTILIZERS, etc.
VALUE
$24 BILLION

* DECEMBER 21, 1987-Based on statistics for first 10 months of 1987 only

BUREAU OF MINES, U.S. DEPARTMENT OF THE INTERIOR
(based in part on U.S. Department of Commerce data)

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Iron Ore 78
Iron and Steel 80
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Kyanite and Related Minerals 86
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Manganese 98
Mercury 100
Mica (Natural), Scrap and Flake 102
Mica (Natural), Sheet 104
Molybdenum 106
Nickel 108
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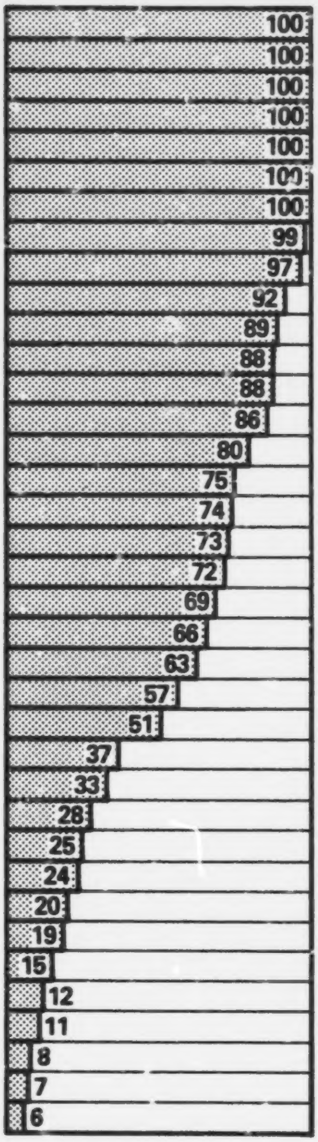
1987 NET IMPORT RELIANCE e/ 1/ OF SELECTED NONFUEL MINERAL MATERIALS AS A PERCENT OF APPARENT CONSUMPTION 2/



		MAJOR SOURCES
ARSENIC	100	Sweden, Canada, Mexico
COLUMBIUM	100	Brazil, Canada, Thailand, Nigeria
GRAPHITE	100	Mexico, China, Brazil, Madagascar
MANGANESE	100	Republic of So. Africa, France, Gabon, Brazil
MICA (sheet)	100	India, Belgium, Japan, France
STRONTIUM (celestite)	100	Mexico Spain, China
YTTRIUM	100	Australia
GEM STONES (natural & synthetic)	99	Bel.-Lux., Israel, India, Republic of So. Africa
BAUXITE & ALUMINA	97	Australia, Guinea, Jamaica, Suriname
TANTALUM	92	Thailand, Brazil, Australia, Canada
DIAMOND (industrial stones)	89	Republic of So. Africa, UK, Ireland, Bel.-Lux.
FLUORSPAR	88	Mexico, Republic of So. Africa, Spain, Italy, China
PT-GROUP METALS	88	Republic of So. Africa, UK, U.S.S.R.
COBALT	86	Zaire, Zambia, Canada, Norway
TUNGSTEN	80	China, Canada, Bolivia, Portugal
CHROMIUM	75	Republic of So. Africa, Zimbabwe, Turkey, Yugo.
NICKEL	74	Canada, Australia, Norway, Botswana
TIN	73	Brazil, Thailand, Indonesia, Bolivia
POTASH	72	Canada, Israel, German Dem. Rep., U.S.S.R.
ZINC	69	Canada, Mexico, Peru, Australia
CADMIUM	66	Canada, Australia, Mexico, Fed. Rep. of Germany
BARITE	63	China, Morocco, India
SILVER	57	Canada, Mexico, UK, Peru
ASBESTOS	51	Canada, Republic of So. Africa
GYPSUM	37	Canada, Mexico, Spain
SILICON	33	Brazil, Canada, Norway, Venezuela
IRON ORE	28	Canada, Brazil, Venezuela, Liberia
COPPER	25	Canada, Chile, Peru, Zaire, Zambia, Mexico
ALUMINUM	24	Canada, Japan, Venezuela, Brazil
CEMENT	20	Canada, Mexico, Spain
IRON & STEEL	19	EEC, Japan Canada, Republic of Korea
LEAD	15	Canada, Mexico, Peru, Australia, Honduras
SALT	12	Canada, Mexico, Bahamas, Chile, Spain
BERYLLIUM	11	Brazil, China, Switzerland, Republic of So. Africa
TITANIUM (sponge metal)	8	Japan, U.S.S.R.
NITROGEN	7	Canada, U.S.S.R., Trinidad & Tobago, Mexico
SULFUR	6	Canada, Mexico

e/ Estimated.

1/ Net import reliance = imports − exports + adjustments for Government and industry stock changes.

2/ Apparent consumption = U.S. primary + secondary production + net import reliance.

Note:
For a number of minerals, net import reliance data are withheld or incomplete. However, commodities for which sufficient data are available to indicate a significant degree of import dependency include: andalusite (Republic of South Africa), antimony (China, Republic of South Africa, Mexico, Bolivia), bismuth (Mexico, Belgium-Luxembourg, Peru, United Kingdom), gallium (Switzerland, France, Federal Republic of Germany, United Kingdom), germanium (Belgium-Luxembourg, China, United Kingdom, France), iodine (Japan, Chile), ilmenite (Australia, Canada, Republic of South Africa), mercury (Spain, Algeria, Turkey, China), rhenium (Chile, Federal Republic of Germany), rutile (Australia, Republic of South Africa, Sierra Leone), and vanadium (Republic of South Africa, European Communities, Canada).

SIGNIFICANT EVENTS IN 1987 1/

NATIONAL ECONOMIC PERFORMANCE

Real economic growth for the year will most likely exceed the Administration's estimate of 3.2%, up from 2.9% in 1986, unless consumers change their spending patterns more than expected as a result of the October stock market decline. The economy grew at a real annual rate of 3.7% in the first three quarters of the year. Analysts agree that the stock market decline will slow economic growth—most have lowered their growth expectations for 1988 by about 1%—but few would argue that the economy will slow significantly in the fourth quarter of 1987.

During this economic recovery, personal consumption expenditures provided the main impetus for growth and a deeping trade deficit, the main hindrance to growth. In 1987, however, personal consumption expenditures grew at a lower rate than the overall economy. Much of the economic growth resulted from a reduced trade deficit and growing investment by business in equipment to improve productivity and to meet the domestic and foreign demand for products. The declining value of the dollar resulted in a better competitive position for U.S. goods but also contributed to a rising rate of inflation as imports rose in price. Inflation, as measured by the fixed-weighted index for gross national product, was still far below the rates in the early 1980's, however. More than 2 million jobs were created during the year, predominantly in the service sectors of the economy, and the monthly unemployment rate in September fell to the lowest level in a decade. Then, after 13 months of decline, the unemployment rate edged up 0.1 percentage point to 5.9% in October.

The health of the domestic mineral and mineral material industries is determined predominantly by growth of nonresidential and residential fixed investment and the defense and durable goods sectors of the economy. Those four sectors accounted for some $56 billion of the $106 billion real growth in 1986 but only $44 billion of the $134 billion of real growth in the first three quarters of 1987. Increased interest rates, high consumer debt and tax-law changes, which reduced favorable tax treatment for corporate investment, contributed to the declining growth of expenditure in these sectors. Although manufacturing output increased during the year, with capacity utilization rates moving over 80% for the first time since 1985, there was still plenty of excess capacity, so firms concentrated their capital investments in equipment to improve or maintain efficiency rather than in new plants to expand capacity.

LEGISLATION AND GOVERNMENT PROGRAMS

The Comprehensive Anti-Apartheid Act of 1986 (Public Law 99-440) restricted or banned the U.S. importation of gold coins minted in the Republic of South Africa and materials produced by parastatal organizations (organizations of which the Government has some ownership), such as iron and steel products, coal, and crude oil. U.S. exports of refined petroleum to the Republic of South Africa were also banned. Section 303(a) of the act states that "no article which is grown, produced, manufactured by, marketed or otherwise exported by a parastatal organization of South Africa may be imported into the United States...except for those strategic minerals for which the President has certified to the Congress that the quantities essential for the economy or defense of the United States are unavailable from reliable and secure suppliers...." The Secretary of State certified to Congress on January 7, 1987, the following materials for exception under Section 303(a)(2):

- Andalusite
- Antimony
- Asbestos, Chrysotile
- Chromium (includes ferrochromium)
- Cobalt
- Diamonds, Industrial (natural)
- Manganese (includes ferromanganese and ferrosilicomanganese)
- Platinum Group Metals
- Rutile (includes titanium-bearing slag)
- Vanadium (includes ferrovanadium)

In 1987 the program of upgrading National Defense Stockpile ferroalloy materials continued. Contracts for the fourth and fifth years of the upgrading of chromite ore to ferrochromium and metallurgical manganese ore to high-carbon ferromanganese were awarded. The contractors were paid through barter arrangements using excess stockpile materials currently authorized for disposal such as antimony, tin, and ores and concentrates of tungsten.

1/ Figures and trends are based on data for the first 10 months of 1987 and reflect views held in November when this document was prepared.

The Stockpile goal for germanium was raised from 30,000 kilograms to 146,000 kilograms and, 7,000 kilograms was purchased during the year. The General Services Administration (GSA) plans to purchase germanium at the rate of 30,000 kilograms per year until the goal is met if such purchases can be made without disrupting the market. Contracts to purchase 30 short tons of beryllium were awarded during the year.

The framework for a U.S.-Canada free trade agreement was completed in October. The pact will eliminate all tariffs and most nontariff barriers between the two countries by 1999, thereby creating the world's largest open market. The expansion of trade is expected to generate 5% higher growth for Canada and up to 1% higher growth for the United States by the end of the century. Legislative approval of the treaty by both countries is still required. Currently, the U.S. trade deficit with Canada is second only to its deficit with Japan. Canada is the largest supplier of nonfuel minerals to the United States.

Work continues at the Environmental Protection Agency (EPA) on the development of a mining waste regulatory program under the nonhazardous solid wastes provisions (subtitle D) of the Resources Conservation and Recovery Act (RCRA). EPA's Detailed Management Plan, published in July, calls for release of the second mining waste Report to Congress in January 1988 and the publication of the proposed mining waste regulatory program in early 1989. In the 1988 report, EPA will address the need to regulate smelting and refining wastes from the lead, zinc, copper, and aluminum industries as RCRA subtitle C hazardous wastes. The Bureau of Mines is continuing to work with EPA to ensure the availability of the best information for the development of the mining and mineral processing solid waste regulatory program.

EPA continued its regulatory impact analysis of the proposed ban and phase-out of asbestos and asbestos products. EPA also reviewed the National Emission Standards for Hazardous Air Pollutants and began surveying the producers of garnet, gold, kyanite, limestone, talc, taconite, tungsten, and vermiculite to determine the asbestos fiber content and total mineral fiber content of mine emissions. The Occupational Safety and Health Administration extended an administrative stay on the regulation governing exposure to nonasbestiform amphiboles while it continued studying the economic impact of the regulation on the mining and construction industries.

INDUSTRY ACTIVITIES

Decreasing imports, low inventory levels, and a steady demand for many goods increased commodity prices and improved the output and profit picture of many industrial firms, including mineral and mineral material producers, during the first three quarters of 1987. The Federal Reserve Board's index for industrial production for the United States for the first three quarters of the year was about 3% higher than the 1986 annual average. Average capacity utilization for the same period was up 1% from the annual 1986 average. Profits for manufacturers were up 18% in the second quarter compared with those of the like period in 1986 although profits in most of the durable good sectors were down. Real spending for new plant and equipment was expected to expand 1.4%, according to a survey conducted by the U.S. Department of Commerce in July and August. Total employment for the manufacturing and mining sectors was up 330,000 from October 1986 to October 1987. The impact of the October stock market decline on these growth trends is uncertain, but as stated at the outset is estimated to be moderate for the last quarter. Because prices and output for most mineral commodities in the United States were up in 1987, the value of raw nonfuel minerals production in the United States increased 9%.

Value of raw nonfuel mineral
production in the United States
(Million current dollars)

	1985	1986	1987
Metals----------------	5,629	5,814	7,446
Industrial Minerals--	17,681	17,644	18,016
Total 1/-------------	23,309	23,457	25,462

1/ Data may not add to total shown because of independent rounding.

FERROUS METALS

In general, ferrous metal prices firmed and metal production increased during most of the year. The balance of trade in ferrous metals was aided by competitive prices of domestic producers and voluntary restraint agreements that limited imports of specific products. Overall growth in the ferrous metals industries is closely tied to expenditures in capital goods, and therefore growth is dependent upon spending for plant expansions and other major improvement projects. The uncertainty about interest rates coupled with a wait-and-see attitude by large segments of industry kept major new expansion and improvement projects on hold for most of the year. However, for those plans already initiated in 1986, when interest rates were lower, spending for capital goods contributed to the upward pressure on prices of alloying metals such as nickel and chromium. The decline in the stock market in the fourth quarter of 1987 forced the domestic iron ore industry into an even more insecure position. A continuation of the Government program for upgrading stockpiled ores into ferroalloys assisted that segment of the ferrous metals industry in maintaining a degree of domestic ferroalloy capacity that might otherwise have been shuttered. Uncertainty caused by possible Government sanctions against the Republic of South Africa continued to cast doubt on sources of supply for several ferrous metal commodities. The U.S.-Canada free trade agreement could ultimately have a bearing on the supply of nickel, cobalt, columbium, iron ore, pig iron, iron and steel scrap, and other commodities.

Conditions for the domestic iron and steel industry improved because of lower imports and higher prices. Imports of steel were restricted by trade agreements with exporting countries. Furthermore, the lower value of the dollar in international trade tended to raise prices and reduce quantities of imports. Demand for domestic steel was higher, and with further plant closures, operating rates rose to about 85% of capability. Nonetheless, demand for steel remained weak relative to that of the 1970's. However, the lower value of the dollar helped steel-consuming industries such as automobile and machinery manufacturers to compete with foreign producers. Most steel companies reported profits on their steel operations, but industry restructuring continued. These improved conditions were generally felt throughout the industry, especially by major integrated companies and by ferrous foundries and industries supplying such commodities as ferroalloys and ferrous scrap. Operating rates averaged about 40% of installed capacity for domestic producers of the bulk ferroalloys of chromium, manganese, and silicon. The increased steel demand resulted in higher prices for ferrous scrap, and ferroalloy prices showed a rising trend. Three integrated steel companies were in bankruptcy and others were heavily burdened by debt and pension obligations.

Among industries linked with basic steel production, the U.S. iron ore industry was an exception to the general improvement shown in other sectors. Domestic iron ore prices weakened in 1987, and the financial difficulties with some of the major firms appear to have worsened with further hardening of credit. Shipments showed an increase, but much of this was used to replenish stocks, which had fallen to record-low levels during the winter. Consumption of ore and agglomerates remained depressed despite the labor settlement of a major steelmaker.

Demand for refractory metals in 1987 generally turned upward compared with that of the previous year, partly owing to increased investment in new plants and facilities, particularly in the chemical and petrochemical industries, which are large users of nickel- and chromium-bearing stainless steels. The relatively low interest rates of 1987 resulted in significant spending for capital equipment. These purchases had been deferred for a number of years. Also, demand for alloy and specialty steels used in construction, transportation, and consumer durables improved, creating upward pressure on prices of some other alloying metals, including molybdenum. Although demand was strong in many sectors, the increases in consumption did not occur in all refractory metals. The major markets for cobalt, representing diverse sectors of the economy--aircraft, magnetic materials, and driers used in paints—were not as strong. The aerospace sector which consumes significant quantities of nickel, chromium, cobalt, and tantalum, reported a 4% decrease in retained earnings at the end of the second quarter of 1987 compared with those of the similar period of 1986.

A stabilization of oil prices contributed to a limited recovery in sectors where cobalt-bearing tungsten carbide is used in oil exploration drill bits, and in the nickel market, where alloy and stainless steels are used in drill pipe and production equipment. In addition, there were continued high levels of automobile production, with an attendant requirement for cutting tool inserts for metalworking.

Improved market conditions in the alloying sector were reflected in rising prices for certain refractory metals. Chromium prices firmed in the fourth quarter and nickel prices were at their highest level since the early 1980's, as stocks were drawn down and production worldwide remained generally constant. Demand in stainless steel, the major use of these commodities, was strong, resulting in a tight market for ferrochromium and charge-grade nickel. For example, prices for charge-grade high-carbon ferrochromium increased about 5% in each of the first two quarters of 1987 and the price of electrolytic nickel rose about 60% during the year.

These improved market conditions affected, to a lesser extent, the price of other alloying refractory metals, including molybdenum, rhenium, cobalt, and tungsten. However, weak demand and high inventories continued to hold down prices for columbium and tantalum. In the case of cobalt, efforts by producers to maintain the price near $7.00 per pound were successful. In spite of an improvement in the international competitiveness of domestic firms, which was caused by a generally weak U.S. dollar, domestic producers of tungsten concentrate could not operate because of low prices resulting from imports of concentrate and intermediate products from China. In addition, those firms that were primarily molybdenum producers were forced to limit production, partly owing to byproduct and coproduct molybdenum production from copper operations.

Domestic producers of several commodities petitioned the Office of the U.S. Trade Representative (USTR) for relief from low-priced foreign imports. An "orderly marketing agreement," which will restrict imports of ammonium paratungstate and tungstic acid from China over the next 4 years, was negotiate between the Governments of the United States and China. In addition, the private sector petitioned the USTR to take action to deny General System of Preferences status for various forms of molybdenum, columbium, and ferrochromium being imported from Chile, Brazil, and Zimbabwe, respectively.

NONFERROUS METALS

Reduced production costs, increased byproduct production, and higher metal prices in 1987 led to increased mine output of copper and zinc in the United States. Increased zinc mine production resulted from the opening of a new gold-silver mine in Montana, and the reopening of a silver-lead mine in Idaho and a lead mine in Missouri, from which zinc was produced as a byproduct. Reopening of a zinc secondary metal plant in Michigan early in 1987 led to increased domestic output of zinc metal. However, mine production of lead declined to the lowest level since 1968, despite good market growth and a 60% increase in the average price of lead. This apparent paradox in lead mining was believed to be partly the result of a continuing trend of high grading in recent years at some mines owing to low prices that existed during 1982-86. Indeed, high grading in recent years at some lead mines in the United States and in the rest of the world prompted the Bureau of Mines to lower its estimate of world lead reserves.

A marked increase in the average price of copper, low inventories, and continuing productivity improvements and restructuring efforts of the domestic industry, such as the construction of efficient flash smelting facilities, led to higher metal output despite the closing of two smelters. Recycling of lead battery scrap increased sharply and resulted in higher metal output for the year. Primary aluminum metal output in the United States also rose, but continuing the trend of the last 4 years, overall domestic capacity again decreased as producers continued to close inefficient operations. U.S. import reliance for the major nonferrous metals declined slightly in 1987, reversing the trend of recent years.

Improvements in domestic demand for aluminum, copper, and lead and the accompanying increases, in prices were due chiefly to generally improved economic activity, especially in the electrical and construction sectors, increases in the per unit use of copper in motor vehicles, and a continuing increase in the number of registered vehicles needing lead replacement batteries. The drop in domestic output of automobiles was believed to be the principal cause of slightly lower domestic zinc demand, as measured by apparent consumption.

The prices of gold and platinum-group metals (PGM) continued a 2-year trend of sharp increases and these metals remained a major focus of exploration and development worldwide. The reserve positions of both gold and PGM were improved significantly as a result of these activities over the past 3 to 4 years. The average price of silver also rose dramatically, reversing a 3-year downward trend. Domestic mine output of the precious metals increased except for refinery output of PGM, which declined slightly. PGM concentrates, produced from ore mined from the

Stillwater Complex in Montana, which began production in early 1987, were shipped to Belgium for refining. The increase in domestically mined silver was a result of increased byproduct silver production from almost 40 gold mines and the opening or reopening of several silver mines. Reported domestic industrial consumption of gold and silver increased slightly. The sharp declines in reported industrial consumption of and apparent demand for PGM were unexpected but in part reflected the downturn in domestic output of catalysts for motor vehicles, the major use for PGM. Expansion of PGM mining and processing capacity in the Republic of South Africa continued owing to the higher prices and anticipated increases in demand in Europe as the use of PGM catalysts to control automobile emissions become more widespread.

Spurred by continued increases in orders for commercial aircraft, consumption of titanium metal rose significantly in 1987. Although domestic sponge prices remained low compared with those of previous years, and despite the shutdown of one producer, domestic production of titanium sponge metal increased, bringing the operating rate of the industry up to about two thirds of capacity.

Domestic production and consumption of titanium dioxide pigments, used primarily in paints, paper, and plastics, continued at record-high levels for the fifth consecutive year, with consumption of a little over 1 million tons in 1987. As a result of continuing high worldwide demand for titanium dioxide pigments, expansion of existing plants and construction of new titanium dioxide facilities were planned in the United States and several other countries. The steadily rising worldwide demand for titanium mineral raw materials, ilmenite and rutile, led to further increases in exploration activities and expansion of the titanium reserve base. Titanium mining and mineral processing capability was expanded in Australia, Canada, China, India, Norway, Sierra Leone, and the Republic of South Africa.

Consumption of magnesium metal increased markedly owing to the increased use of magnesium in aluminum alloys, its principal application. Domestic production and consumption of magnesium compounds were about level in 1987, but the market for magnesium refractories, the principal use for magnesium compounds, continued to shrink because of development of advanced longer life refractories and technological changes in iron and steel production techniques.

The world tin industry continued to adjust following the market collapse in 1985, when the International Tin Council (ITC) could no longer support the tin price. Tin trading on the London Metal Exchange (LME) remained suspended and closures of tin mines and production cutbacks continued throughout the world. Some mines were kept operating by financial support from some Governments, while others cut back production or closed. Some LME trading firms and banks that had loaned funds to the ITC for earlier tin price support purchases continued litigation against the ITC and its member Governments that have not repaid the loans. Tin prices rose somewhat during 1987 but remained at a level that was historically low and at which many of the world's tin mines could not operate profitably.

Other nonferrous metals such as the rare earths, yttrium, indium, gallium, tellurium, selenium, and zirconium are finding increasing uses in advanced materials by providing these materials with special chemical and physical properties needed to make computers, military and commercial aircraft and spacecraft, and electrical, communication, and transportation equipment work faster and more efficiently. Many of these metals are byproducts or coproducts of the recovery or refining of other metals such as copper, lead, zinc, and aluminum, and their supply, while generally adequate through 1987, was contingent on the demand, and hence the production, of these other metals. In 1987 the price of many of these so-called "high-tech" metals increased dramatically, especially the price for indium, which was being intensely researched for use in semiconductors, in solar cells, and as a coating on glass to block ultraviolet and infrared radiation. The price of tellurium, which is used in defense and space electronics where mercury-cadmium-tellurium has become an important semiconductor, especially for infrared imaging systems, also increased dramatically. The price of gallium, which is mainly a byproduct of aluminum production, remained unchanged as consumption declined sharply in 1987 but remained at a historically high level, being double that of 1985. The continued worldwide expansion of gallium production facilities foreshadowed significant potential for increased use of gallium in advanced materials.

Except for samarium, the 14 rare-earth metals and yttrium were in abundant world supply and domestic prices of various rare-earth metals, compounds, and mixtures were more or less unchanged. Although domestic mine production and demand declined somewhat, the demand pattern continued to shift toward individual rare-earth compounds, metals, and special mixtures, and the domestic industry's capacity to produce and separate these products increased. Demand for neodymium, may have high future growth potential as its use in permanent magnets becomes further commercialized. Improved knowledge of the properties of the rare earths continued to indicate important new potential applications. The development in 1987 of ceramic superconducting materials composed of certain oxides of rare earths and yttrium in conjunction with various other metal oxides, including copper oxide, that operate at markedly higher temperatures than do conventional superconducting materials could eventually lead to a very large market for the rare earths.

INDUSTRIAL MINERALS

Demand for building materials such as construction aggregate, gypsum, and cement remained strong. Consumer demand for cement remained strong, slightly exceeding the 1986 record level. U.S. reliance on imported cement continued at an accelerated pace reaching a record high level of 18 million short tons and accounting for 20% of consumption compared with just 4% in 1981. Mexico continued to capture a larger share of the import market with 28% of the total, exceeding imports from Canada for the second consecutive year. Foreign ownership of domestic production capacity, primarily by Western European firms exceeded 50% compared with 22% in 1981. Crushed stone production was over 1 billion short tons for the third consecutive year, while construction sand and gravel production was 883 million tons. Foreign acquisition of cement, crushed stone, and sand and gravel production capacity continued to grow during 1987. By yearend, approximately 54% of cement capacity had been acquired by foreign firms. Foreign acquisition of crushed stone and sand and gravel operations, while not as significant, experienced accelerated growth during 1986-87 and now amounts to about 3% to 5% of total production capacity. Gypsum wallboard shipments remained at record-high levels because of continued strength in residential construction. Domestic demand for fertilizer raw materials continued to be affected by programs that removed crop land from production. Demand for ammonia, phosphate rock, and potash was essentially unchanged from that of 1986. Sulfur was the only primary raw material for fertilizer manufacture that experienced a significant increase in demand. Industrial minerals producers continued to work toward higher valued products of greater purity that command a higher price, such as high-purity silica sand and calcium carbonate, surface-modified clays, and wollastonite used in the sophisticated glass and filler and extender markets. Environmental issues, mergers and acquisitions, international trade, and Government legislation all had significant impacts on the production of industrial minerals.

The U.S. phosphate industry operated at an estimated 60% of capacity, and employment increased 30% above that of 1986. The domestic demand for phosphate fertilizers was curtailed by crop acreage reduction programs. Export demand for phosphate rock and phosphate fertilizers was similar to that of 1986, but prospects for improvement appear remote as new competitive supplies will probably become available from foreign producers. The average selling price of phosphate rock in the United States declined to $20 per metric ton, f.o.b. mine, $2 less than that of 1986. The profit margin was insufficient to recover capital for new or replacement mines.

The decline in international sulfur prices, that began in the fourth quarter of 1985, continued; world prices dropped nearly 40% from those of mid-1985. Despite a 7% increase in domestic sulfur demand, output from Frasch mines was 18% lower than that of 1986, mainly because decreased world prices reduced export opportunities. Lower world prices also allowed Canadian sulfur to be more competitive in the U.S. market. Sulfur exports from the United States were off 26% while imports increased 39%.

Two potash producers in New Mexico filed antidumping petitions against the Canadian potash producers. The International Trade Commission found a likelihood of damage to the U.S. potash industry, and the International Trade Administration of the U.S. Department of Commerce set preliminary dumping duties. The Canadian potash producers raised their prices to attempt to cover the costly dumping duties and generally raised the effective price of potash, to the benefit of U.S. producers.

The abrasive materials industry underwent a year of consolidations through mergers, sales, and closures. The synthetic diamond and polycrystalline diamond industry was affected by the major producer's purchase and subsequent closing of a competing company. In the manufactured abrasives industry, one firm completely withdrew from the industry by the sale of its silicon carbide facilities to one competitor and its fused aluminum oxide facilities to another. In the metallic abrasive industry, one firm closed its steel shot and grit manufacturing facilities, and another manufactured steel shot and grit for the first time. A tripoli producer was purchased by the U.S. subsidary of a Canadian company. The consolidations should result in a stronger and more profitable industry because of better cost control and more efficient use of production capacity.

Gradually increasing oil prices during the year from under $15 per barrel to about $20 per barrel in the last quarter caused an increase in drilling activities which consume large quantities of barite and bentonite clay. Drilling rigs in this same time period rose from a low of about 750 to over 1,000. The large excess of barite and bentonite capacity in the industry was somewhat rationalized during the year by the purchase of one company by another and merger of others.

A company with a deposit in California found investment capital to develop a new technology to solution-mine colemanite and produce boric acid. The new process would have lower energy, operating, and capital costs compared with those of present operating facilities.

Faced with increasing competition from imports, primarily from Israel, a bromine producer sold its assets to another bromine company, reducing the number of companies producing bromine and derivative chemicals to four.

A Japanese company opened a new iodine plant in Vici, OK, on October 1, and planned to produce about 40 tons of iodine per month by yearend. The new plant planned to employ 25 people. This would be the third iodine producing plant in the United States.

Global capacity reductions combined with level U.S. and world consumption have ended the decline in fluorspar prices that began during the 1982 recession. South African producers have taken the lead by negotiating a price increase in contracts signed in 1987. Consumers in the United States showed a greater desire for fluorspar with low levels of certain impurities, a fact which provided an advantage for the Republic of South Africa and China, which reentered the U.S. market in 1987 after a year's absence. An international agreement to freeze and later reduce consumption of chlorofluorocarbons that are believed to destroy ozone molecules in the upper atmosphere was signed by 24 nations in Montreal, Canada in September. When implemented in 1989, the agreement is expected initially to decrease consumption of fluorspar worldwide. However, replacement fluorochemicals are being developed, and when commercialized could increase fluorspar consumption.

The improved condition of the aluminum industry, a major user of lithium, prompted both U.S. lithium producers to raise their prices for lithium carbonate between 3% and 5%. Imports of lithium ores increased significantly, with Canadian and Australian ores taking up a larger market share than in 1986. Lithium metal imports increased owing to the demand for the product in the expanding lithium battery industry; imports of other lithium products remained about the same as those of 1986.

The third largest natural soda ash facility in Wyoming was sold twice in 1987. The most recent owner, a major European soda ash producer, may displace some of its own production capacity with imports of soda ash from its new Wyoming operation. An Australian mineral company signed a letter of intent to purchase the natural soda ash resource at Owens Lake, CA. This company, which is partly owned by Chinese business interests, intends to export soda ash to the Far East.

Production of salt for chloralkali manufacture increased because of a strong demand for chlorine and caustic-soda-based products. Because of declining sales in certain markets, one major salt company announced it was available for acquisition. Another major domestic salt producer signed a letter of intent to purchase its competitor, pending U.S. Department of Justice approval.

ALUMINUM 1/

(Data in thousand metric tons of metal, unless noted)

1. **Domestic Production and Use:** In 1987, 12 companies operated 23 primary aluminum reduction plants, with 3 firms accounting for 63% of production. Washington, Oregon, and Montana accounted for 36% of the production; Indiana, Kentucky, Missouri, and Tennessee 26%; Ohio, Texas, South Carolina, and North Carolina 23%; other States 15%. Based on published market prices, output of primary metal in 1987 was valued at $5.0 billion. Aluminum consumption by 25,000 firms was centered in the east-central United States. Packaging accounted for an estimated 29% of domestic consumption in 1987, building, 22%; transportation, 22%; electrical, 10%; consumer durables, 8%; and other uses, 9%.

2. **Salient Statistics--United States:**

	1983	1984	1985	1986	1987 e/
Production: Primary	3,353	4,099	3,500	3,037	3,200
Secondary (from old scrap)	820	825	850	784	850
Imports for consumption	1,091	1,477	1,420	1,967	1,900
Exports	776	734	908	753	890
Consumption, apparent 2/	5,035	5,279	5,174	5,143	5,295
Price, ingot, average, cents per pound:					
U.S. producer list	77.8	81.0	81.0	81.0	NA
U.S. market (spot)	68.3	61.1	48.8	55.9	71.0
Stocks, aluminum industry, yearend	2,265	2,653	2,343	2,235	2,000
Employment: Primary reduction e/	21,000	20,000	19,000	17,500	17,000
Secondary smelter e/	4,000	3,800	3,800	3,600	3,600
Net import reliance 3/ as a percent of apparent consumption	17	7	16	26	24

3. **Recycling:** Aluminum recovery from scrap generated from current operations (new scrap) accounted for about 54% of the total recovery from purchased scrap. Discarded aluminum products (old scrap) such as cans accounted for the remainder. Aluminum recovery from old scrap, estimated at 850,000 tons in 1987, was about 16% of apparent consumption.

4. **Import Sources (1983-86):** Canada, 55%; Japan, 9%; Venezuela, 6%; Brazil, 4%; other, 26%.

5. **Tariff:** In 1987, material classified under TSUS number 618.25 and imported from countries designated under the Generalized System of Preferences had a special free tariff rate.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Unwrought (in coils)	618.01	2.6% ad val.	18.5% ad val.
Unwrought (other than aluminum silicon alloys)	618.02	Free	11.0% ad val.
Wrought (bars, plates, sheets, strip)	618.25	3.0% ad val.	13.5% ad val.

6. **Depletion Allowance:** None. 1/

7. **Government Stockpile:**

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 6 Months
Aluminum	635	2	-	--

e/ Estimated. NA Not available.

1/ See also Bauxite.

2/ Domestic primary metal production plus recovery from old aluminum scrap and net import reliance.

3/ Defined as imports - exports + adjustments for Government and industry stock changes.

Prepared by Patricia A. Plunkert, telephone number (202) 634-1080.

8. Events, Trends, and Issues: U.S. production of primary aluminum increased in 1987 as domestic producers reopened previously idled potlines owing to higher prices and reduced inventories throughout the world. Imports of ingot, scrap, and other forms were estimated at 1.9 million tons, a slight decrease from those of 1986, while exports increased 18% in 1987 compared with those of 1986. The price of primary aluminum increased dramatically in 1987 and reached its highest level since early 1980. In January 1987, the average monthly spot price for primary ingot, as quoted by Metals Week, was 54.6 cents per pound. The price increased steadily and reached 84.6 cents in October. Prices on the Commodity Exchange Inc. (COMEX) and London Metal Exchange (LME) followed the trend of spot prices. This rapid rise in primary ingot prices carried over into the aluminum scrap market. The buying price for used beverage can (UBC) scrap increased approximately 70% during the year. In early October, UBC scrap prices reached a record high of 61 cents per pound before declining to 56 cents later that month.

U.S. primary producers began 1987 with about 72% of the 4 million tons of annual capacity in operation. By yearend, the operating capacity had increased to about 90%. Of the 23 primary aluminum reduction plants in operation during 1987, 15 were operating at full capacity and the remainder were partially operating. In July, a major domestic aluminum producer wrote off the remaining 105,000 tons of previously idled capacity at its Chalmette, LA, aluminum plant and an idle 37,000-ton-per-year potline at Ravenswood, WV. In Washington, the Goldendale and Vancouver smelters were purchased by private investors. The Goldendale plant reportedly would be operated on a tolling basis, thereby increasing the total amount of domestic primary aluminum capacity committed to tolling operations to approximately 750,000 tons per year.

World primary aluminum smelter capacity increased slightly in 1987. Although Japan and the United States decreased their annual capacity, these reductions were offset by capacity expansions in Canada, China, and India. Primary aluminum smelters in Brazil, Cameroon, Ghana, Indonesia, and Suriname were operated at reduced capacity during the year because of cutbacks in hydroelectric power brought on by drought conditions in these countries.

9. World Plant Production and Capacity:

	Production		Yearend Capacity	
	1986	1987 e/	1986	1987 e/
United States	3,037	3,200	4,038	3,895
Australia	882	1,000	1,012	1,012
Canada	1,360	1,500	1,462	1,577
Norway	712	790	770	831
Other Market Economy Countries	6,151	6,180	7,010	6,865
China e/	410	420	413	513
U.S.S.R. e/	2,300	2,350	2,640	2,740
Other Centrally Planned Economies e/	462	460	601	601
World Total	15,314	15,900	17,946	18,034

10. World Resources: Domestic aluminum requirements cannot be met by domestic bauxite resources. Potential domestic nonbauxitic aluminum resources are abundant and could meet domestic aluminum demand. However, no processes for using these resources have been proven economically competitive with bauxite. The world reserve base for bauxite is sufficient to meet world demand for metal beyond the year 2000. 1/

11. Substitutes: Copper can replace aluminum in electrical applications and magnesium, titanium, and steel can be used instead of aluminum for structural and ground transportation uses. Composites, wood, and steel may be used in place of aluminum for construction, and glass, plastics, paper, and steel may replace aluminum in packaging.

ANTIMONY

(Data in short tons of antimony content, unless noted)

1. Domestic Production and Use: Primary antimony metal and oxide were produced by eight companies operating eight plants utilizing both foreign and domestic material. Two of these plants were located in Texas and one each in Maryland, Montana, Nebraska, New Jersey, Ohio, and Tennessee. Antimony continued to be recovered as a byproduct from smelting of domestic lead ores. The estimated value of total primary antimony metal and oxide production in 1987 was $49 million. Antimony was consumed at about 250 plants in States east of the Mississippi River, accounting for approximately 90% of reported primary consumption. The principal uses of primary antimony were flame retardants, 65%; transportation, including batteries, 10%; chemicals, 10%; ceramics and glass, 5%; and other, 10%.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production: Mine--Silver-copper and stibnite ores	838	557	W	W	W
Lead ore	W	W	W	W	W
Refinery--Primary plants 1/	14,557	17,639	16,449	17,978	19,000
Secondary plants	14,204	14,823	15,030	15,029	16,000
Imports for consumption	12,885	23,089	20,694	25,401	26,000
Exports of metal, alloys, and oxide	669	991	1,247	1,175	900
Shipments from Govt. stockpile excesses	1,863	69	928	460	1,200
Consumption: Reported, primary antimony	10,418	12,465	11,697	10,956	11,500
Apparent 2/	29,712	33,261	W	W	W
Price, average, cents per pound 3/	91.3	151.2	131.1	121.9	110.0
Stocks, yearend	3,935	6,895	6,040	6,130	6,000
Employment, plant e/	130	130	130	120	120
Net import reliance 4/ as a percent of apparent consumption	54	58	W	W	W

3. Recycling: Approximately 14,400 tons of antimony was recovered from old scrap. Approximately 95% of the total secondary antimony was recovered as antimonial lead, most of which was consumed by the battery industry.

4. Import Sources (1983-86): Metal--China, 62%; Mexico, 18%; Hong Kong, 8%; Bolivia, 4%; other, 8%.
Ores and concentrate--Mexico, 34%; Bolivia, 18%; China, 14%; Thailand, 10%; other, 24%.
Oxide--Republic of South Africa, 39%; China, 27%; France, 11%; Bolivia, 10%; other, 13%.
Total--China, 32%; Republic of South Africa, 22%; Mexico, 12%; Bolivia, 11%; other, 23%.

5. Tariff: In 1987, antimony metal imported from Bolivia and Mexico was duty free.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore	601.03	Free	Free
Needle or liquated	603.10	0.1¢/lb.	0.25¢/lb.
Metal, unwrought	632.02	Free	2¢/lb.
Oxide	417.50	Free	2¢/lb.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Includes antimony recovered from domestic and foreign ores.
2/ Antimony recovered from lead ores is excluded for the years 1983-84.
3/ New York dealer price for 99.5% to 99.6% metal, c.i.f. U.S. ports.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ See page 184 for definitions.
6/ Excludes U.S. production.

Prepared by Thomas O. Llewellyn, telephone number (202) 634-1083.

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Antimony	36,000	36,207	207	1,171

8. Events, Trends, and Issues: An Idaho company, which recovered antimony as a byproduct of a complex silver-copper-antimony sulfide ore (tetrahedrite), closed its mining operations in 1986, and remained closed in 1987. Antimony continued to be recovered from the residues resulting from smelting of domestic lead ores. In 1987, imports for consumption increased slightly, and China, Mexico and the Republic of South Africa remained the major suppliers of antimony materials to the United States. Refinery production of primary antimony increased about 6%. The General Services Administration (GSA) continued the offering of excess antimony metal from the National Defense Stockpile as tender for its program to upgrade stockpile ferroalloys. On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Apartheid Act of 1986, antimony was certified by the U.S. Department of State as a strategic mineral essential for the economy or defense of the United States that is unavailable in adequate quantities from reliable and secure suppliers.

The consumption of antimony oxide as a flame retardant continued as the dominant market for primary antimony. The use of antimony as a hardening agent in lead-acid batteries, which has declined over the last several years, was believed to have leveled off, as the range in the types of alloys used in automotive batteries has begun to narrow.

Antimony metal prices, published by Metals Week, started the year ranging from $1.05 to $1.10 per pound, increasing to $1.18 to $1.23 in May, and subsequently falling to a range of $1.10 to $1.16 in October.

Environmental and ecological problems associated with the treatment of antimony metal and ores are minimal as emissions and effluents are controlled at the processing plants.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 5/	Reserve Base 5/
	1986	1987 e/		
United States	W	W	90,000	100,000
Bolivia	11,350	10,000	340,000	350,000
Mexico	4,400	4,000	200,000	250,000
South Africa, Republic of	8,200	8,000	260,000	280,000
Yugoslavia	1,300	1,200	100,000	100,000
Other Market Economy Countries	12,770	12,000	890,000	1,135,000
Centrally Planned Economies	28,000	28,000	2,750,000	2,960,000
World Total	6/66,020	6/63,200	4,630,000	5,175,000

10. World Resources: United States resources are mainly in Idaho, Nevada, Alaska, and Montana. Principal identified world resources, estimated at 5.6 million tons, are in China, Bolivia, the U.S.S.R., the Republic of South Africa, and Mexico. Additional antimony resources may occur in Mississippi Valley-type lead deposits in the Eastern United States.

11. Substitutes: Compounds of titanium, zinc, chromium, tin, and zirconium may be substituted for antimony chemicals in paint, pigments, frits, and enamels. Combinations of calcium, strontium, tin, copper, selenium, sulfur, and cadmium can be used as substitutes for hardening lead. Selected organic compounds and hydrated aluminum oxide are widely accepted alternative materials in flame-retardant systems.

ARSENIC

(Data in metric tons, unless noted)

1. **Domestic Production and Use**: Arsenic trioxide was refined from imported low-grade arsenic trioxide and then converted to arsenic acid for use in the production of arsenical wood preservatives by a company in Conley, GA. A company in Charlotte, NC, produced arsenic acid for wood preservatives from low-grade imported materials and a company in Laramie, WY, produced small quantities of arsenic acid from arsenic recovered from domestic lead smelter flue dusts. Nearly all arsenic was consumed in compound form, mainly by four producers of agricultural chemicals and three producers of wood preservative chemicals. Metallic arsenic was used primarily in nonferrous alloys. Approximately 15 tons of high-purity arsenic metal was used in the electronics industry for semiconductor materials. The estimated end-use distribution of arsenic in 1987 was 74% in wood preservatives, 19% in agricultural chemicals (principally herbicides and desiccants), 3% in glass, 2% in nonferrous alloys, and 2% in other uses. The total value of arsenic metal and compounds consumed was estimated to be more than $30 million.

2. **Salient Statistics--United States**:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, refinery, arsenic trioxide 1/ 2/	7,300	6,800	2,200	-	-
Imports for consumption:					
Metal	243	304	407	395	530
Arsenic trioxide	10,186	13,985	16,472	25,728	27,000
Arsenic compounds 3/	3,555	2,635	2,200	1,473	2,300
Exports, compounds	85	76	158	217	80
Consumption, apparent, arsenic content 2/	13,600	17,300	17,900	21,800	23,000
Price, cents per pound, yearend:					
Trioxide, domestic, 95% As_2O_3, f.o.b. Tacoma, WA	33	33	33	NA	NA
Trioxide, Mexican, 99.13% As_2O_3, f.o.b. Laredo, TX	45	42	42	44	44
Metal, domestic, 99% As, 2,000-lb. lots	225	210	210	185	4/ 140
Stocks, yearend, refinery, arsenic content 2/	3,100	3,300	1,100	370	-
Employment		Not available			
Net import reliance 5/ as percent of apparent consumption	60	70	90	100	100

3. **Recycling**: None.

4. **Import Sources (1983-86)**: Sweden, 23%; Canada, 18%; Mexico, 17%; France, 15%; other, 27%.

5. **Tariff**:

Tariff:	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Metal	632.04	Free	6¢/lb
Trioxide & sulfide	417.62 & 417.60	Free	Free
Other compounds	417.64	3.7% ad val.	25.0% ad val.

6. **Depletion Allowance**: 14% (Domestic), 14% (Foreign).

7. **Government Stockpile**: None.

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e/ Estimated. NA Not available.

1/ Arsenic trioxide (As_2O_3) contains approximately 76% arsenic by weight.

2/ Previously withheld to avoid disclosing company proprietary data. Sole refiner ceased production in 1985; permission to publish data received in 1986.

3/ Arsenic compounds include arsenic sulfide (TSUS 417.60), arsenic acid (TSUS 416.05), sodium arsenate (TSUS 420.70), lead arsenate (TSUS 419.00), arsenic compounds, n.e.c. (TSUS 417.64).

4/ Imported metal for 1987.

5/ Defined as imports - exports + adjustments for Government and industry stock changes.

6/ See page 184 for definitions.

7/ Includes estimated production of low-grade material exported to the United States for further refining.

Prepared by Neldon L. Jensen, telephone number (202) 634-1058.

8. Events, Trends, and Issues: The apparent consumption of arsenic in 1987 increased by about 6% above the 1986 level. Increased consumption of arsenic trioxide by the wood preservative industry in formulating chromated copper arsenate (CCA) wood preservatives accounted for most of the increase in demand. An increasing measure of technological interest was focused on gallium arsenide, a superior semiconductor, and especially on the development of gallium arsenide integrated circuits, which were expected to replace silicon-based circuits in high-speed computers and several other electronics applications. The quantity of arsenic consumed for this use, about 15 tons, was negligible as compared with total consumption, but it was highly purified metal, and the market value comprised about 5% of the total value of arsenic consumed domestically.

Arsenic has commonly been regarded as a troublesome impurity which complicates the smelting and refining of the base and precious metals with which it occurs in nature. The cost of ensuring that this highly toxic metal does not contaminate the environment has risen in recent years, further reducing the incentive to recover it for use. Thus, with the closing in 1985 of the sole domestic producer, the United States became completely dependent on foreign suppliers for arsenic. That dependency remained in 1987 and may well continue indefinitely.

9. World Refinery Production, Reserves, and Reserve Base:

	Refinery Production		Reserves 6/	Reserve Base 6/
	1986	1987 e/		
United States	-	-	50,000	80,000
Belgium	3,000	3,000	950,000	1,420,000
Canada	7/ 3,000	7/ 3,000		
Chile	6,000	6,000		
France	10,000	10,000		
Mexico	6,000	6,000		
Namibia	1,936	2,000		
Peru	1,210	1,000		
Philippines	5,000	5,000		
Sweden	10,000	10,000		
Other Market Economy Countries	1,200	1,000		
U.S.S.R.	8,100	8,000		
World Total (may be rounded)	55,500	55,000	1,000,000	1,500,000

10. World Resources: World resources of copper and lead contain about 11 million tons of arsenic. Substantial resources of arsenic occur in copper ores in northern Peru and the Philippines, and in copper-gold ores in Chile. In addition, world gold resources, particularly in Canada, contain substantial resources of arsenic.

11. Substitutes: Substitutes for arsenic exist in most major end uses, although arsenic may be the preferred material owing to lower cost and superior qualities. In agricultural uses, synthetic organic compounds such as paraquat may be substituted for arsenical pesticides, herbicides and desiccants. The wood preservatives pentachlorophenol and creosote may be substituted for chromated copper arsenate where odor and paintability are not problems. Non-wood alternatives such as concrete and steel may be substituted for arsenical pressure-treated wood. There are no available alternatives to the use of arsenicals as growth regulators for grapefruit and for control of some grape diseases.

ASBESTOS

(Data in thousand metric tons, unless noted)

1. **Domestic Production and Use:** The total estimated value of 1987 domestic production (sales) was $18 million. Three firms in California and Vermont accounted for 100% of domestic production. Asbestos was consumed in friction products, 22%; roofing products, 17%; asbestos-cement pipe, 17%; coatings and compounds, 15%; paper, 11%; and other, 18%.

2. **Salient Statistics—United States:**

	1983	1984	1985	1986	1987 e/
Production (sales), mine	70	57	57	51	52
Imports for consumption	196	210	142	108	98
Exports	55	40	46	47	58
Shipments from Govt. stockpile excesses			None		
Consumption, apparent	217	226	162	120	107
Price: Average value, dollars per ton, f.o.b. mine	399	422	357	338	342
Stocks, producer, yearend	79	80	71	63	48
Employment, mine and mill e/	190	190	200	250	260
Net import reliance 1/ as a percent of apparent consumption	68	75	65	58	51

3. **Recycling:** Insignificant.

4. **Import Sources (1983-86):** Canada, 94%; Republic of South Africa, 6%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Asbestos	518.11	Free	Free

6. **Depletion Allowance:** 22% (Domestic), 10% (Foreign).

7. **Government Stockpile:** In addition to the quantity shown below, the stockpile contained 831 tons of nonstockpile grade chrysotile and less than 1 ton of nonstockpile grade amosite.

Stockpile Status--9-30-87
(metric tons)

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Chrysotile stockpile grade	2,722	8,879	4,250	-
Amosite stockpile grade	15,422	30,849	-	-
Crocidolite	-	33	-	-

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e/ Estimated.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ See page 184 for definitions.

Prepared by Robert L. Virta, telephone number (202) 634-1206.

8. Events, Trends, and Issues: Adverse publicity on asbestos-related health risks and the proposed Environmental Protection Agency (EPA) ban/phase-out of asbestos and asbestos-containing products continued to affect U.S. market segments. While domestic production (sales) increased slightly, domestic demand for asbestos decreased 11% from that of 1986.

Asbestos imports decreased 9% from those of 1986. Canada continued to be the major source of imported asbestos. Crocidolite was imported from the Republic of South Africa.

EPA continued a regulatory impact analysis of its proposed ban/phase-out of asbestos and asbestos-containing products. The agency also reviewed the national emission standards for hazardous air pollutants and began surveying the producers of nine mineral commodities to determine the asbestos content and the total mineral fiber content of mine emissions.

On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Apartheid Act of 1986, chrysotile asbestos was certified by the U.S. Department of State as a strategic mineral essential for the economy or defense of the United States that is unavailable in adequate quantities from reliable and secure suppliers.

Other issues affecting the asbestos industry were the pending International Labor Organization provision supporting the controlled use of asbestos, the increased amount of Federal and State legislation regarding asbestos-containing insulation material in commercial and public buildings, and concern over the availability and health risk posed by asbestos substitutes.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 2/	Reserve Base 2/
	1986	1987 e/		
United States (sales)	51	52	4,000	8,000
Canada (shipments)	640	660	40,000	47,000
South Africa, Republic of	140	120	5,000	8,000
Other Market Economy Countries	640	620	11,000	15,000
Centrally Planned Economies	3,051	3,050	50,000	65,000
World Total	4,522	4,502	110,000	143,000

10. World Resources: The world has 200 million tons of identified resources and an additional 45 million tons classified as hypothetical resources. The U.S. resources are large but are mostly short fibers.

11. Substitutes: Glass fiber and mineral wool were the most successful substitutes for asbestos, particularly for thermal insulations. Natural and synthetic organic fiber, carbon fiber, refractory fiber, and metallic fiber were other fiber types which were being investigated as asbestos substitutes. Several nonfibrous minerals were considered as possible asbestos substitutes in products where the reinforcement properties of fibers were not required. No single substitute was as versatile and cost effective as asbestos.

BARITE

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: Barite production in 1987 increased after 3 consecutive years of decline from the 1981 record high of 2.8 million tons valued at $102 million to 0.3 million tons valued at $14 million. The leading six companies supplied over 90% of the output. Production came from six States, with nearly 63% of the total from Nevada. Other leading States were Georgia and Missouri. About 1.3 million tons of ground barite from domestic production and imports were sold in 1987. Over 65% of the barite produced was used as a weighting agent in oil- and gas-well-drilling fluids, mostly in the gulf and pacific coast areas. Barite was also used in paints, and rubber, and for producing barium chemicals and glass.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, mine 1/	754	775	739	297	344
Imports for consumption (crude barite)	1,396	1,731	2,056	745	600
Exports	23	1	6	7	9
Consumption, apparent (crude barite)	2,127	2,505	2,789	1,035	935
Consumption 2/ (ground and crushed)	2,745	2,883	2,184	1,216	1,300
Price, average value, dollars per ton, mine	38.73	32.83	29.09	41.50	40.92
Stocks, producer, yearend	Not available				
Employment, mine and mill e/	1,000	1,000	900	400	400
Net import reliance 3/ as a percent of apparent consumption	65	69	74	71	63

3. Recycling: None.

4. Import Sources (1983-86): China, 52%; Morocco, 15%; India, 12%; other, 21%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude barite	472.10	$1.27/long ton	$4.00/long ton
Ground barite	472.12	$3.25/long ton	$7.50/long ton
Blanc fixe	472.14	0.2¢/lb	1.25¢/lb

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated.
1/ Sold or used by producers.
2/ Domestic and imported crude barite sold or used by grinding establishments.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions.
5/ Excludes other Centrally Planned Economies.

Prepared by Sarkis G. Ampian, telephone number (202) 634-1180.

8. Events, Trends, and Issues: The demand for barite in 1987 increased slightly over that of the 30-year low recorded in 1986. This minor improvement was caused by Middle East tensions which mitigated the negative combination of fluctuating low world oil prices and short-term economic uncertainties. The domestic oil rig count during the 9 months of 1987 gradually recovered to an average of nearly 1,000 rigs, or less than a 100-rig improvement over that of 1986. A week in May, 1987, recorded only 744 operating rigs. The postwar high was 4,530 rigs in operation during a week in December, 1981, while the low of 663 was during a week of July, 1986. It is estimated that in 1988 domestic mine production will be 0.5 million tons and apparent U.S. consumption will be 1.5 million tons.

Imports for consumption of lower cost foreign barite for the sixth consecutive year exceeded domestic production. Ground drilling-mud-grade-barite, largely from Morocco and in smaller amounts, continued to compete with domestically ground barite in the already depressed gulf coast area markets. Consolidations in the oil service business, including mines and grinding plants, owing to the uncertainty in world oil prices were commonplace during the year.

The low cost and technical advantages of barite preclude substitutes in the drilling mud market. Transportation costs, the availability of lower cost imports, and the growth rate of barite demand affect the development of domestic barite resources. The principal environmental impact of chemically inert barite is in land disturbance normally associated with mining. Barite dust from grinding plants can be controlled satisfactorily by air pollution control equipment.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States 1/	297	344	30,000	55,000
Canada	41	40	3,000	7,000
France	160	150	2,000	2,500
Germany, Federal Republic of	220	40	1,000	1,000
India	386	350	30,000	32,000
Ireland	231	150	1,000	1,500
Italy	126	100	2,000	2,000
Mexico	413	350	7,000	8,000
Morocco	209	200	10,000	11,000
Peru	33	50	2,000	2,000
Thailand	220	200	7,000	8,500
Yugoslavia	40	40	2,000	9,000
Other Market Economy Countries	1,060	900	19,000	88,000
China e/	1,100	1,000	40,000	150,000
U.S.S.R. e/	595	500	10,000	75,000
Other Centrally Planned Economies e/	273	270	NA	20,000
World Total (may be rounded)	5,400	4,700	5/166,000	473,000

10. World Resources: In the United States, identified resources of barite are estimated to be 100 million tons, and the hypothetical resources include an additional 150 million tons. The world's barite resources in all categories are about 2 billion tons, but only about 500 million tons are identified.

11. Substitutes: In the drilling mud market, alternatives to barite include celestite, ilmenite, iron ores, and synthetic hematite manufactured in the Federal Republic of Germany. However, none of these substitutes has had major impact on the barite drilling mud industry.

BAUXITE 1/

(Data in thousand metric dry tons, unless noted)

1. **Domestic Production and Use:** Bauxite was produced from surface mines in Alabama and Arkansas by four companies in 1987. The entire ore output of 560,000 tons, valued at $9.4 million, went to nonmetallic uses such as abrasives, chemicals, proppants, refractories, and specialty aluminas. Approximately 89% of the total 8.8 million tons of domestic and imported bauxite consumed in 1987 was processed into alumina, 88% of which was supplied to primary aluminum smelters. Annual capacity of domestic alumina plants at yearend was 4.6 million tons at the four operational refineries.

2. **Salient Statistics--United States:** 2/

	1983	1984	1985	1986	1987 e/
Production, mine	679	856	674	510	560
Imports of bauxite for consumption 3/4/	7,900	9,800	7,700	6,900	10,000
Imports of alumina	4,030	4,288	3,827	3,603	4,100
Exports of bauxite 4/	104	110	69	85	75
Exports of alumina	602	648	316	487	572
Shipments from Govt. stockpile excesses			None		
Consumption, apparent, bauxite and alumina 5/	3,867	4,389	4,143	3,202	4,283
Price, dollars per ton, f.o.b. mine	13-20	13-20	13-20	13-17	13-17
Stocks, industry, yearend, bauxite	5,600	4,900	3,600	3,300	3,000
Employment, mine	155	180	110	90	85
Net import reliance 6/ as a percent of apparent consumption	96	96	96	96	97

3. **Recycling:** None.

4. **Import Sources (1983-86):** Bauxite: Guinea, 45%; Jamaica, 32%; Australia, 6%; Brazil, 6%; other, 11%.
   Alumina: Australia, 77%; Jamaica, 9%; Suriname, 8%; other, 6%.

5. **Tariff:** Import duties on bauxite and alumina were abolished in 1971 by Public Law 92-151. Only imports from non-most-favored-nations, as defined by the 1979 Tokyo Round tariff agreements, are dutiable, and no country so designated supplied bauxite or alumina to the United States during the first 9 months of 1987.

6. **Depletion Allowance:** 22% (Domestic), 14% (Foreign).

7. **Government Stockpile:** Stockpile goals and inventories for abrasive grade, metal grade, and refractory grade bauxite remained unchanged from those of 1986.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Bauxite-abrasive grade	1,016	-	-	-
Bauxite-metal grade:				
Jamaica type	21,337	12,658	-	-
Suriname type	6,198	5,385	-	-
Bauxite-refractory grade, calcined	1,422	279	-	-

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e/ Estimated.
1/ See also Aluminum.
2/ Includes U.S. Virgin Islands.
3/ Includes abrasive grade consumed in Canada.
4/ Includes all forms of bauxite, expressed as dry equivalent weights.
5/ The sum of the aluminum equivalents of U.S. bauxite production and net import reliance.
6/ Defined as imports - exports + adjustments for Government and industry stock changes (all in aluminum equivalents).
7/ See page 184 for definitions.

Prepared by Luke H. Baumgardner, telephone number (202) 634-1081.

8. Events, Trends, and Issues: Increased primary aluminum demand in 1987 resulted in substantial increases in domestic alumina production and in bauxite and alumina imports. Alumina refinery capacity remained essentially unchanged from yearend 1986; however, apparent capacity utilization increased from 77% to 85% by yearend 1987. Prices for calcined alumina moved upward in response to increases in world demand as the alumina oversupply of recent years situation eased.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 7/	Reserve Base 7/
	1986	1987 e/		
United States	510	560	38,000	40,000
Australia	32,431	32,800	4,440,000	4,600,000
Brazil	6,224	6,500	2,800,000	2,900,000
Greece	2,500	2,500	600,000	650,000
Guinea	12,130	12,300	5,600,000	5,900,000
Guyana	1,466	1,800	700,000	900,000
India	2,270	2,700	1,000,000	1,200,000
Jamaica	6,964	7,200	2,000,000	2,000,000
Suriname	3,847	2,400	575,000	600,000
Venezuela	-	-	320,000	350,000
Yugoslavia	3,300	3,300	350,000	400,000
Other Market Economy Countries	4,424	4,300	2,600,000	2,900,000
Hungary	3,022	3,100	300,000	300,000
U.S.S.R.	4,600	4,600	300,000	300,000
Other Centrally Planned Economies	2,250	2,300	200,000	200,000
World Total (may be rounded)	85,938	86,360	21,800,000	23,200,000

10. World Resources: Bauxite resources (reserves plus subeconomic and undiscovered deposits) are estimated to be 55 billion to 75 billion tons. The resources in millions of tons are as follows: the United States, 300 to 325; Caribbean and Central America Region, 2,000 to 3,000; South America, 19,000 to 25,000; Europe, 3,000 to 4,000; Africa, 15,000 to 20,000; Asia, 8,000 to 13,000; and Oceania, 7,000 to 10,000. Domestic resources of bauxite are inadequate to meet long-term demand, but the United States and most other major aluminum producing countries have virtually inexhaustible subeconomic resources of aluminum in materials other than bauxite.

11. Substitutes: Although bauxite is the only raw material used in the production of alumina on a commercial scale in the United States, research on processes to produce alumina from nonbauxitic materials has shown that the vast U.S. resource of clay is a technically feasible source of alumina. Other domestic raw materials such as anorthosite, alunite, coal wastes, and oil shales offer additional potential alumina sources. Although it would require new plants using new technology, alumina from these nonbauxitic materials could satisfy the demand for primary metal, refractories, aluminum chemicals, and abrasives. Synthetic mullite, produced from kyanite and sillimanite, could substitute for bauxite-based refractories, while silicon carbide and alumina-zirconia are acceptable, though more costly, substitutes for bauxite-based abrasives.

BERYLLIUM

(Data in short tons of contained beryllium, unless noted)

1. **Domestic Production and Use**: One company in Utah mined bertrandite and converted the ore, as well as domestic and imported beryl, into beryllium hydroxide at its Utah mill. This company then processed the hydroxide into beryllium alloys, oxide, and metal at its plant in Ohio. The other company in the industry bought imported beryl and produced beryllium alloys at a plant in Pennsylvania. Beryllium consumption of 315 tons was valued at about $140 million, based on the producer price for vacuum-cast ingots. Beryllium was used as an alloy and metal in aerospace and defense applications, 22%; as an alloy and oxide in electrical equipment, 36%; as an alloy and oxide in electronic components, 20%; and as alloys, compounds, and metal in other applications, 22%.

2. **Salient Statistics--United States**:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, mine	267	241	230	261	280
Imports for consumption	97	88	122	81	140
Exports	19	20	60	40	100
Shipments from Govt. stockpile excesses 1/	-	(31)	(30)	-	-
Consumption, apparent	279	333	289	306	315
Price, dollars:					
Domestic, metal, vacuum cast ingot, per pound	206	213	225	225	225
Domestic, metal, powder blend, per pound	178	178	196	196	196
Domestic, beryllium-copper master alloy, per pound of contained beryllium	130	140	144	152	160
Imported ore, per s.t.u. (20 lbs) BeO	126	88	87	88	85
Stocks, consumer, yearend	281	226	199	195	200
Employment:					
Mine, fulltime equivalent employees e/	25	25	25	25	25
Primary refineries e/	400	400	400	400	400
Net import reliance 2/ as a percent of apparent consumption	4	28	20	15	11

3. **Recycling**: Old scrap, insignificant. Substantial quantities of new scrap generated in the processing of beryllium-copper alloys were recycled.

4. **Import Sources (1983-86)**: Brazil, 56%; China, 25%; Switzerland, 5%; Republic of South Africa, 4%; other, 10%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrates	601.09	Free	Free
Unwrought beryllium waste and scrap	628.05	8.5% ad val.	25.0% ad val.
Beryllium, wrought	628.10	9.0% ad val.	45.0% ad val.
Beryllium-copper master alloy	612.20	6.0% ad val.	28.0% ad val.
Beryllium oxide or carbonate	417.90	3.7% ad val.	25.0% ad val.
Other beryllium compounds	417.92	3.7% ad val.	25.0% ad val.

6. **Depletion Allowance**: 22% (Domestic), 14% (Foreign).

e/ Estimated. NA Not available.
1/ Data in parentheses denote stockpile acquisitions.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.
4/ Excludes China.

Prepared by Deborah A. Kramer, telephone number (202) 634-1083.

7. **Government Stockpile:**

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Beryl ore (11% BeO)	720	720	-	-
Beryllium-copper master alloy	316	295	-	-
Beryllium metal	400	290	-	-

8. **Events, Trends, and Issues:** Demand for beryllium-copper alloys in electronic components increased from that of 1986. With greater emphasis on miniaturization and faster processing speeds in computer equipment and increased usage of electronic components in automobiles, beryllium-copper alloys were used as connectors, switches, and relays.

The two U.S. companies that formed a joint venture to develop a bertrandite property in Texas in 1986, also formed a joint venture to produce beryllium metal. The joint-venture company reportedly planned to produce a small quantity of beryllium metal and also submitted a bid to the General Services Administration (GSA) to supply beryllium metal to the National Defense Stockpile (NDS). In 1987, the GSA solicited bids to supply 60,000 pounds of beryllium metal to the NDS. In addition to the joint-venture firm, the beryllium producer in Utah reportedly submitted a bid to supply metal to the NDS.

Beryllium dust and fines have been recognized as the cause of berylliosis, a chronic lung disease. Harmful effects are minimized by maintaining a clean workplace and requiring the use of safety equipment.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production	
	1986	1987 e/
United States	261	280
Argentina	1	1
Brazil	42	50
Madagascar	2	2
Portugal	1	1
Rwanda	1	1
Zimbabwe	2	2
Other Market Economy Countries	1	1
China	NA	60
U.S.S.R.	84	85
World Total	4/395	483

Reserves and Reserve Base 3/

The United States has very little beryl that can be economically handsorted from pegmatites. The Spor Mountain area, Utah, contains a large reserve base of bertrandite, which was being mined. Domestic deposits of bertrandite ores contain about 14,000 tons of beryllium. The world reserves and reserve base are not adequately delineated.

10. **World Resources:** No quantitative information is available on foreign resources of beryllium-bearing minerals and rocks. The identified resources of beryllium in known domestic deposits are estimated at 66,000 tons of contained beryllium.

11. **Substitutes:** Because of the relatively high price of beryllium, uses are expected to continue principally in applications which require its light weight, high strength, and high thermal conductivity. Steel, titanium, or graphite composites may be substituted for beryllium metal, and phosphor bronze for beryllium-copper alloys, but with substantial loss of performance.

BISMUTH

(Data in thousand pounds of bismuth content, unless noted)

1. Domestic Production and Use: Domestic production was derived from processing intermediate metallurgical products, such as lead bullion, which contain bismuth as a minor constituent. One company in Nebraska accounted for all domestic primary production. Consumption continued to be centered in the industrial belt of the northern and eastern United States. Forty-nine companies east of the Mississippi River accounted for 89% of the bismuth consumption. Based on an estimated average annual dealer price of $3.28 per pound, reported consumption was valued at $10.5 million. Bismuth was used in pharmaceuticals and chemicals, 50%; manufacturing of parts for machinery, 22%; primary metal industries, 26%; and other uses, 2%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, refinery	W	W	W	W	W
Imports for consumption	1,972	1,948	1,999	2,490	3,700
Exports 1/	306	312	269	93	60
Shipments from Govt. stockpile excesses			None		
Consumption, reported	2,285	2,648	2,643	2,919	3,200
Price, average, domestic dealer, dollars per pound	1.72	4.27	5.18	3.23	3.28
Stocks, yearend, consumer	577	480	507	763	700
Employment, plant e/	30	30	30	30	30
Net import reliance 2/ as a percent of apparent consumption	W	W	W	W	W

3. Recycling: There is no known trade in old bismuth scrap. Some consumers of fusible alloys reuse these bismuth containing alloys in such applications as holding devices for optical lens grinding.

4. Import Sources (1983-86): Mexico, 31%; Belgium-Luxembourg, 17%; Peru, 17%; United Kingdom, 13%; other, 22%.

5. Tariff: In 1987, bismuth alloys and compounds imported from Mexico and Peru had a special free tariff rate.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Metal, unwrought	632.10	Free	7.5% ad val.
Alloys	632.66	5.5% ad val.	45.0% ad val.
Compounds	418.00 & 423.80	7.0% ad val.	35.0% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 months
Bismuth	2,200	2,081	-	-

e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Includes bismuth, bismuth alloys, and waste and scrap.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ Most of reserve and reserve base is bismuth recoverable from the lead reserve and reserve base.
4/ See page 184 for definitions.
5/ Excludes U.S. production.

Prepared by Robert D. Brown, Jr., telephone number (202) 634-1063.

8. Events, Trends, and Issues: Primary production of bismuth in the United States remained about the same as that of 1986, as the single producing plant continued to operate well below its estimated annual capacity of 1.1 million pounds. Consumption of bismuth increased moderately in 1987. It is estimated that in 1988, U.S. reported consumption of bismuth will be 3.3 million pounds.

The sole domestic primary bismuth producer did not publish a bismuth list price in 1987. Dealer prices generally increased from $2.65 to $3.50 per pound during the first half of the year. Then they increased rapidly to $5.00 per pound in August and softened to $4.85 at yearend.

The steel industry continued to experiment with and maintain commercial production of free-machining alloy bar steels that used bismuth as an additive. Research was conducted on bismuth usage as a smoke and fire retardant and in electronic applications.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves [3] [4]	Reserve Base [3] [4]
	1986	1987 [e]		
United States	W	W	20,000	30,000
Australia	2,200	2,400	40,000	60,000
Bolivia	180	200	10,000	12,000
Canada	440	200	12,000	20,000
Japan	1,400	1,400	50,000	127,000
Korea, Republic of	220	200	8,000	10,000
Mexico	1,980	2,000	12,000	30,000
Peru	1,500	2,000	24,000	92,000
Other Market Economy Countries	-	-	8,000	22,000
Centrally Planned Economies	1,050	1,000	16,000	47,000
World Total	[5] 8,970	[5] 9,400	200,000	450,000

10. World Resources: Bismuth in the United States is expected to continue to be recovered as a byproduct from domestic and imported lead ores and concentrates. Other potential sources include byproduct recovery from molybdenum and tungsten ores, and ash from West Virginia coal. Bismuth is known to occur in lead deposits in the Appalachian Mountains from Maine to Virginia. Large unmeasured quantities of bismuth are also present in Australia, Bolivia, China, Mexico, North Korea, Peru, and the Republic of Korea.

11. Substitutes: Antibiotics, magnesia, and alumina can replace bismuth in pharmaceutical uses. Mica and fishscales are acceptable substitutes in cosmetics. Iron, phosphorus, and potassium can be used for bismuth as a catalyst for production of acrylonitrile. Tellurium can replace bismuth as a steel additive, and plastics can substitute for bismuth alloys in holding devices and jigs for some applications. Generally, however, these substitutes are not competitive with bismuth on the basis of cost or quality.

BORON

(Data in thousand short tons of boric oxide (B_2O_3), unless noted)

1. Domestic Production and Use: Total production of boric oxide contained in minerals and compounds in 1987 was estimated to be valued at $440 million. Firms primarily in the North Central and Eastern States were the chief consumers. Principal uses for boron compounds consumed in the United States in 1987 were estimated as glass products, 59%; soaps and detergents, 7%; agriculture, 4%; and other uses, 30%.

   Domestic production, by two companies, of boron minerals primarily in the form of sodium borates was centered in southern California. The largest producer operated an open-pit tincal and kernite mine and associated compound plants. A second firm using Searles Lake brines as raw material at two plants accounted for the remaining output.

2. Salient Statistics—United States:

	1983	1984	1985	1986	1987 e/
Production 1/	637	667	636	629	686
Imports for consumption: Colemanite	16	20	33	16	5
Ulexite	11	47	31	42	26
Boric acid	4	4	6	3	1
Exports, gross weight of boric acid and refined borates	263	2/621	2/672	2/666	2/650
Consumption: Apparent	405	464	481	453	498
Reported	341	375	360	338	380
Price, dollars per ton, granulated pentahydrate borax in bulk, f.o.b. mine	201	208	214	220	226
Stocks, yearend 3/	Not available				
Employment	1,400	2,400	1,300	1,300	1,250
Net import reliance 4/ as a percent of apparent consumption	Net exporter				

3. Recycling: Insignificant.

4. Import Sources (1983-86): Boric acid: Turkey, 69%; Italy, 21%; Argentina, 8%; France, 2%.
   Colemanite: Turkey, 100%.
   Ulexite: Turkey, 100%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Boric acid	416.10	1.5% ad val.	8.5% ad val.
Calcium borate, crude	418.12	Free	Free
Mineral articles and substances (ulexite)	523.81	Free	Free

6. Depletion Allowance: Borax 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated.
1/ Minerals and compounds sold or used by producers, includes both actual mine production and marketable products.
2/ Source: The Journal of Commerce Port Import/Export Reporting Service. Includes crude borates.
3/ Stocks data are not available and are assumed to be zero for net import reliance and apparent consumption calculations.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ See page 184 for definitions.
6/ Gross weight of ore in thousand short tons.

Prepared by Phyllis A. Lyday, telephone number (202) 634-1177.

8. **Events, Trends, and Issues:** The United States was the world's largest producer of boron compounds during 1987. The United States exports about one-half of domestic production to processing facilities in Spain, the Netherlands, Italy, and India. This exported material competes with borax, colemanite, and ulexite from Turkey, the second largest producer of boron in the world.

One company with a borate deposit in southern California acquired funding, began pumping tests, and constructed a pilot plant as part of a feasibility study of boric acid production by the solution mining of colemanite, a calcium borate. The new process was expected to have lower energy, operating, and capital costs compared with existing methods to produce boric acid.

It is estimated that in 1988, domestic production of boric oxide will be 650,000 short tons and U.S. apparent consumption will be 493,000 short tons.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production		Reserves 5/ 6/	Reserve Base 5/ 6/
	1986	1987 e/		
United States 1/	629	686	115,000	230,000
Argentina	29	29	3,000	10,000
Bolivia	-	-	6,000	21,000
Chile	1	1	14,000	45,000
Peru	2	2	7,000	24,000
Turkey	505	510	120,000	160,000
China	6	6	30,000	40,000
U.S.S.R.	44	44	60,000	150,000
World Total (may be rounded)	1,200	1,300	355,000	680,000

10. **World Resources:** Large domestic resources of borate materials occur in California, chiefly in sediments and their contained brines. Extensive resources also occur in Turkey. World resources are adequate to supply needs at current rates for the foreseeable future.

11. **Substitutes:** Substitution for borates is possible in such applications as soaps, detergents, enamel, agriculture, and insulation.

BROMINE

(Data in million pounds of bromine content, unless noted)

1. Domestic Production and Use: The quantity of bromine sold or used remained unchanged, ending a 7-year downward trend. Five companies operating in Michigan and Arkansas accounted for 100% of elemental bromine production estimated at $105 million. Arkansas accounted for 96% of nameplate production capacity. Plant capacity did not reflect production capacity, which was dependent upon brine supplies, bromine concentration in the brine, and individual plant extraction processes.

   Usage of bromine in fire retardants was estimated to represent 30% of the bromine consumption. Bromine was also used in petroleum, 25%; and sanitary preparations, 15%. Other uses were in photographic film development, intermediate chemicals used in the manufacture of other products, leaded gasoline, and bromide solutions used alone or in combination with calcium chloride in "completion" and "workover" fluids for oil and gas wells.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production 1/	370	385	320	310	310
Imports for consumption, elemental bromine and compounds	16	16	17	19	20
Exports, elemental bromine and compounds	56	113	58	41	40
Consumption, apparent	325	358	279	288	290
Price, cents per pound, bulk, purified bromine	33-34.5	33-34.5	33-34.5	33-34.5	35.0
Stocks, producer, yearend, elemental bromine e/			None		
Employment, plants	410	370	350	300	300
Net import reliance 2/ as a percent of apparent consumption			Net exporter		

3. Recycling: Approximately 5% of the U.S. bromine production was converted to byproduct sodium bromide solutions, which were recycled to obtain elemental bromide.

4. Import Sources (1983-86): Israel, 96%; United Kingdom, 2%; France, 1%; other, 1%.

5. Tariff: In 1987, bromine imported from Israel had a special free tariff rate. In addition, the Free Trade Agreement changed the duty on 19 brominated compounds from Israel.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Bromine	415.05	2.0¢/lb	10¢/lb
Ammonium bromide	3/417.23	3.1% ad val.	25% ad val.
Calcium bromide	3/418.13	Free	25% ad val.
Ethylene dibromide	429.28	0.7¢/lb + 3.5% ad val.	6.0¢/lb + 30% ad val.
Hydrobromic acid	415.45	4.2% ad val.	25% ad val.
Potassium bromate	420.36	3.1% ad val.	25% ad val.
Potassium bromide	420.02	1.5¢/lb	10¢/lb
Methyl bromide	429.48	3.7% ad val.	25% ad val.
Sodium bromate	420.36	3.1% ad val.	25% ad val.
Sodium bromide	420.82	3.0¢/lb	10¢/lb
Tetrabromobisphenol	3/403.54	0.7¢/lb + 19.4% ad val.	7¢/lb + 62% ad val.

e/ Estimated. NA Not available.
1/ Sold or used by U.S. producers.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ New TSUS number effective 1985.
4/ See page 184 for definitions.
5/ From waste bitterns associated with solar salt.
6/ From the Dead Sea.

Prepared by Phyllis A. Lyday, telephone number (202) 634-1177.

6. Depletion Allowance: 5% on brine wells (Domestic and Foreign).

7. Government Stockpile: None.

8. Events, Trends, and Issues: One company in Arkansas that produced bromine from underground brines bought the bromine assets of another producer to reach a combined nameplate capacity of 270 million pounds per year and become the largest bromine company in the United States.

   The Generalized System of Preferences (GSP) for sodium bromide from Israel was suspended on July 1, 1986, subject to review in 1987. On May 19, 1987, the President included eligibility to GSP with respect to sodium bromide from Israel, which again allowed these imports to enter duty-free.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States 1/	310.0	310.0	25,000	25,000
France	42.0	42.0	3,500	3,500
Germany, Federal Republic of	5.5	5.5	80	600
India	.8	.8	5/	5/
Israel	231.5	240.0	6/	6/
Italy	1.0	1.0	5/	5/
Japan	16.7	35.0	1,800	1,800
Spain	.6	.6	5/	5/
United Kingdom	66.0	65.0	5/	5/
China	-	-	NA	NA
U.S.S.R.	143.0	154.0	3,000	3,000
World Total	817.1	855.9	NA	NA

10. World Resources: Resources of bromine are virtually unlimited. The Dead Sea in the Middle East is estimated to contain 1 billion tons of bromine. Seawater contains about 65 parts per million of bromine or an estimated 100 trillion tons. The bromine content of underground water in Poland has been estimated at 36 million tons.

11. Substitutes: Chlorine and iodine may be substituted for bromine in a few chemical reactions and for sanitation purposes. Aniline and some of its derivatives, methanol, ethanol, and gasoline-grade tertiary butyl alcohol are effective nonlead substitutes for ethylene dibromide and lead in gasoline in some cars. There are no comparable substitutes for bromine in various oil and gas well completion and packer applications. Antimony oxide, alumina, organic chlorine compounds, and phosphorus compounds can be substituted for bromine as fire retardants for some uses.

CADMIUM

(Data in metric tons of cadmium content, unless noted)

1. Domestic Production and Use: Cadmium was recovered as a byproduct of smelting domestic and imported zinc concentrates. Domestic refinery output was by four companies operating one plant each in Colorado, Illinois, Oklahoma, and Tennessee. Based on the average producer price, production was valued at $6.3 million. The estimated consumption pattern was coating and plating, 30%; batteries, 30%; pigments, 20%; plastics and synthetic products, 15%; and alloys and other uses, 5%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, refinery	1,052	1,686	1,603	1,486	1,500
Imports for consumption, metal	2,196	1,889	1,988	3,174	3,000
Exports, all forms	170	106	86	38	180
Shipments from Govt. stockpile excesses			None		
Consumption, apparent	3,763	3,300	3,720	4,385	4,400
Price, dollars per pound, producer, in 1 to 5 short ton lots, average	1.13	1.69	1.21	1.25	1.90
Stocks, yearend, producer and distributor	732	901	686	923	850
Employment e/, smelter and refinery	250	250	200	200	200
Net import reliance 1/ as a percent of apparent consumption	72	51	57	66	66

3. Recycling: Cadmium usage was largely dissipative. Recycling has been practical only for nickel-cadmium batteries and some alloys and industrial wastes.

4. Import Sources (1983-86): Metal--Canada, 44%; Australia, 23%; Mexico, 10%; Federal Republic of Germany, 7%; other, 16%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1-1-87	Non-MFN 1-1-87
Flue dust	603.20	Free	Free
Metal	632.14	Free	15¢/lb

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Cadmium	5,307	2,871	-	-

e/ Estimated.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ See page 184 for definitions.

Prepared by Thomas O. Llewellyn, telephone number (202) 634-1083.

8. Events, Trends, and Issues: Domestic cadmium refinery production continued to fall short of satisfying domestic demand, but imports of metal and stock withdrawals made up the shortfall. Of the various applications for cadmium, the usage of cadmium in nickel-cadmium batteries has the highest probable growth potential. Research has provided some potential new uses for cadmium sulfide and cadmium telluride in solar photovoltaic cells.

The domestic producer price range of cadmium at the beginning of 1987 was $1.20 to $1.50 per pound. The price quotes increased during the year and producers listed a price range of $2.75 to $3.50 per pound in early November. Dealer prices, which began the year at $0.97 to $1.05 per pound, fluctuated during the year. By early November, the dealer price was $2.90 to $3.10 per pound. The strength of the cadmium market was attributed, in part, to the four-month strike at a North American lead-zinc operation, the expected increase in demand by a foreign nickel-cadmium battery producer and the excess of world demand over production.

Concern over the dispersal of toxic materials has had the dual effect of increasing cadmium recovery at primary smelters and reducing the amount of cadmium dissipated in the environment through industrial operations.

9. World Refinery Production, Reserves, and Reserve Base:

	Refinery Production		Reserves 2/	Reserve Base 2/
	1986	1987 e/		
United States	1,486	1,500	70,000	210,000
Australia	1,000	1,000	55,000	145,000
Belgium	1,300	1,400	-	-
Canada	1,421	1,500	80,000	170,000
Japan	2,400	2,400	10,000	15,000
Mexico	700	700	35,000	40,000
Other Market Economy Countries	5,660	5,600	215,000	295,000
Centrally Planned Economies	4,290	4,300	70,000	95,000
World Total	18,257	18,400	535,000	970,000

10. World Resources: World resources of cadmium are estimated at about 6 million tons. Because of the geochemical association of zinc and cadmium, resources of cadmium are estimated to be 0.3% of zinc resources. Large potential resources of cadmium are contained in the zinc-bearing coals of mid-continent United States and perhaps in Carboniferous-age coals of other countries. Undiscovered cadmium resources are estimated to be 5 million to 50 million tons of cadmium content depending on the ore-occurrence model used.

11. Substitutes: Coatings of zinc or vapor deposited aluminum can be substituted for some cadmium plating applications. Tin may be used in place of cadmium compounds for plastic stabilizers. Zinc and iron pigments can be used in place of cadmium pigments but often at the risk of reduced performance.

CEMENT

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use:** One State agency and 45 companies operated 143 plants in 41 States to produce 74.5 million tons of portland cement, 3.8 million tons of masonry cement, and minor quantities of calcium aluminate cement in 1987. The value of this production was about $4.5 billion. By yearend, the capacity of 122 plants producing portland cement clinker, including 3 white cement facilities, was 255,000 tons per day. Allowing for an average of about 55 days downtime for maintenance and rebricking kilns, the apparent annual clinker production capacity was 86.5 million tons. An additional 14 plants operated grinding mills only for imported, purchased, or interplant transfers of clinker. Estimated finish-grinding capacity was 102 million tons. The 5 largest companies comprised 31% of the clinker production capacity; and the 10 largest accounted for 52%. Fifty percent of the portland cement production came from six States: California, Texas, Pennsylvania, Michigan, Missouri, and Alabama, in declining order. Uses for domestic cement were 72% for ready-mixed concrete; 12% for concrete products such as block, pipe, and prestressed precast concrete; 5% by building material dealers; 4% by highway contractors; and 7% by other contractors, Government agencies, and miscellaneous users.

2. **Salient Statistics--United States:** 1/

	1983	1984	1985	1986	1987 e/
Production (portland, masonry, and other)	70,420	77,700	77,895	78,786	78,300
Shipments from mills (includes masonry cement)	70,933	80,166	83,032	87,592	88,000
Imports for consumption	4,221	8,689	14,120	16,128	18,000
Exports	118	80	98	59	60
Consumption, apparent 2/	73,435	84,313	87,456	91,501	93,000
Price, average mill value, dollars per ton	49.95	51.80	51.61	50.32	51.00
Stocks, mill, yearend	6,711	6,866	7,232	6,725	6,500
Employment, mine and mill e/	20,000	20,000	19,500	19,500	19,300
Net import reliance 3/ as a percent of apparent consumption	6	10	16	18	20

3. **Recycling:** None.

4. **Import Sources (1983-86):** Canada, 27%; Mexico, 22%; Spain, 21%; other, 30%.

5. **Tariff:** 4/

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
White nonstaining portland cement	511.11	Free	8¢/100 lb
Other hydraulic cement and clinker	511.14	Free	6¢/100 lb

6. **Depletion Allowance:** Certain raw materials for cement production such as limestone, bauxite, and gypsum have depletion allowances.

7. **Government Stockpile:** None.

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e/ Estimated.
1/ Excludes Puerto Rico.
2/ Adjusted to eliminate duplication of imports shipped by domestic cement manufacturers.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ Rates include weight of container.

Prepared by Wilton Johnson, telephone number (202) 634-1184.

8. Events, Trends, and Issues: Total U.S. demand increased slightly. Finished portland and clinker production capacity utilization remained essentially unchanged at 74% and 79%, respectively. Domestic cement shipments to regions of the U.S. increased except for the South which decreased only slightly. The North Central region experienced the largest increase with 6%, followed by the Northeast with 4%. Shipments to the West increased only slightly. It is estimated that 1988 cement production will be 77 million tons and U.S. apparent consumption will be 90 million tons.

The gap between domestic production and demand continued to widen as the industry relied more heavily on imports to meet its customer requirements. Import reliance as a percent of apparent consumption was 20%, surpassing the 18% record level established in 1986.

The trend continued toward consolidation of the industry through acquisition of companies and plants by larger firms, most of which were foreign owned. By yearend, approximately 54% of cement production capacity was foreign owned. To increase efficiency and economy of energy use, cement producers continued to introduce state-of-the-art technology in plant modernization and expansion programs including high-efficiency separators and high-pressure rollers.

Environmental concerns continued to promote the use of state-of-the-art technology to control atmospheric emissions of particulates, a major cost item in cement plant construction, renovation, and maintenance.

9. World Production and Capacity:	Production		Yearend Clinker Capacity	
	1986	1987 e/	1986	1987 e/
United States (includes Puerto Rico)	79,900	79,000	89,000	88,000
France	25,900	26,000	30,000	30,000
Germany, Federal Republic of	29,200	29,500	46,000	46,000
India	35,300	36,000	40,000	42,000
Italy	38,900	39,000	55,000	55,000
Japan	78,500	79,000	110,000	108,000
Spain (includes Canary Islands)	26,500	27,000	39,000	40,000
Other Market Economy Countries	378,200	380,000	510,000	515,000
China	178,000	180,000	200,000	220,000
U.S.S.R.	149,000	150,000	154,000	160,000
Other Centrally Planned Economies	80,494	85,000	110,000	115,000
World Total	1,099,894	1,110,500	1,383,000	1,419,000

10. World Resources: Although domestic resources of raw materials are adequate, they are sometimes remote from cement market areas. Countries deficient in one or more raw materials have experienced little difficulty importing their requirements.

11. Substitutes: Aluminum, steel, fiberglass, wood, stone, and clay products may be used in the building and construction markets.

CESIUM 1/

(Data in pounds of cesium content, unless noted)

1. Domestic Production and Use: One firm in Pennsylvania imported pollucite, the principal commercial ore of cesium, and accounted for all of the domestic output of cesium products. Cesium, usually in the form of chemical compounds, was used in research and development, including the development of magnetohydrodynamic (MHD) electric power generators, thermionic energy converters, and biological research, and was used commercially in electronic, photoelectric and medical applications.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Mine	None				
Metal and compounds	W	W	W	W	W
Imports for consumption:					
Pollucite and metal	Not available				
Cesium compounds including cesium chloride, gross weight	19,000	54,000	51,000	37,000	37,000
Exports	Not available				
Consumption, apparent, metal and compounds	Not available				
Price, dollars:					
Pollucite, per short ton	350-400	350-400	350-400	350-400	350-400
Metal, per pound	275-325	275-325	280-330	280-330	280-330
Cesium oxide, per pound	400	400	400	400	400
Cesium compounds, per pound	32-80	37-86	40-85	40-85	37-80
Stocks, producer, yearend	W	W	W	W	W
Employment, plant e/	25	25	25	25	25
Net import reliance e/ 2/ as a percent of apparent consumption	100	100	100	100	100

3. Recycling: None.

4. Import Sources (1983-86): Pollucite: Canada 100%.
Compounds, including cesium chloride: Federal Republic of Germany, 94%; other, 6%.

5. Tariff:

Tariff:	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrate	601.66	Free	Free
Cesium	415.10	5.3% ad val.	25.0% ad val.
Cesium chloride	418.50	4.0% ad val.	25.0% ad val.
Other compounds	418.52	4.0% ad val.	25.0% ad val.

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ See also Rubidium.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.

Prepared by W. Timothy Adams, telephone number (202) 634-1082.

8. Events, Trends, and Issues: Preliminary data indicate that U.S. demand for cesium in 1987 was about the same as that of 1986. The relatively stronger demand in 1984 and 1985 was attributed to the experimental use of cesium as a catalyst activity promoter in petroleum cracking and petrochemical synthesis.

Future cesium supplies are likely to continue to be dependent upon foreign sources unless domestic deposits are discovered or technology is developed to use low-grade raw materials.

The high cost and extreme reactivity of cesium limit its applications at present.

Because of the small scale of production of cesium products, no significant environmental problems have been encountered.

9. World Mine Production, Reserves, and Reserve Base: Data on mine production of cesium are not available. Cesium forms independent minerals in pegmatites and is commonly obtained as a coproduct in the processing of titanium, beryllium, and lithium minerals. Reserves and the reserve base 3/ are associated mainly with the cesium silicate mineral, pollucite, concentrates of which contain more than 20% cesium.

	Reserves 3/	Reserve Base 3/
Canada	152,000,000	160,000,000
Namibia	16,000,000	20,000,000
Zimbabwe	50,000,000	50,000,000
Other	NA	NA
World total (may be rounded)	220,000,000	230,000,000

10. World Resources: World resources of cesium are not known.

11. Substitutes: The properties of rubidium and its compounds are so similar to those of cesium and its compounds that compounds of rubidium and cesium are used interchangeably in many applications. Certain other elements can be substituted in light-sensing equipment, and potassium may be used instead of cesium in MHD power generation.

CHROMIUM

(Data in thousand short tons, gross weight, unless noted)

1. **Domestic Production and Use**: The United States continued to be one of the world's leading consumers of chromium. Chromite was consumed by four firms producing chromium ferroalloys and metal, seven firms producing refractories, and two firms producing chromium chemicals. Most of these were in the Eastern United States. Of the chromite consumed, the chemical and metallurgical industry used 90% and the refractory industry 10%. Consumption of chromium ferroalloys, metal, and other chromium-containing materials by end use was about as follows: stainless and heat-resisting steel, 79%; full-alloy steel, 8%; superalloys, 3%; and other alloys, 10%. The total value of chromium consumed as chromite and ferrochromium was estimated to be $170 million.

2. **Salient Statistics--United States**: 1/

	1983	1984	1985	1986	1987 e/
Production: Mine			None		
Secondary	77	88	93	92	100
Imports for consumption	231	347	320	385	320
Exports	13	36	41	39	3
Consumption: Reported	301	315	293	381	360
Apparent 2/	329	447	378	447	397
Price, chromite, yearend:					
Turkish, dollars per metric ton, Turkey	110	110	125	125	100
South African, dollars per metric ton, South Africa	52	52	42	42	46
Stocks, consumer, yearend	175	127	122	113	133
Net import reliance 3/ as a percent of apparent consumption	76	80	75	79	75

3. **Recycling**: In 1987, estimated chromium contained in purchased stainless steel scrap amounted to 25% of chromium demand.

4. **Import Sources (1983-86)**: Chromium contained in chromite and ferrochromium: Republic of South Africa, 61%; Turkey, 10%; Zimbabwe, 10%; Yugoslavia, 5%; other, 14%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrate	601.15	Free	Free
Low-carbon ferrochromium	606.22	3.1% ad val.	30% ad val.
High-carbon ferrochromium	606.24	1.9% ad val.	7.5% ad val.

6. **Depletion Allowance**: 22% (Domestic), 14% (Foreign).

7. **Government Stockpile**: The General Services Administration converted about 138,000 tons of chromite to high-carbon ferrochromium in 1987, the fourth year of this conversion program. The Congress has required upgrading of chromite ore to high-carbon ferrochromium during each of fiscal years 1987 through 1993 at the annual rate of not less than 53,500 tons of high-carbon ferrochromium production. The congressional 7-year requirement was made under Title II--National Defense Stockpile of the Defense Authorization Act of 1987. In addition to the data shown, the stockpile contained the following nonstockpile-grade materials: 254,001 tons of metallurgical-grade chromite and 20,762 tons of chromium ferroalloys.

e/ Estimated.
1/ Data in thousand short tons of contained chromium.
2/ Calculated total demand for chromium.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions.
5/ Shipping grade ore is deposit quantity and grade normalized to 45% Cr_2O_3 for high-chromium and high-iron chromite and 35% Cr_2O_3 for high-alumina chromite.

Prepared by John F. Papp, telephone number (202) 634-6092.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Average Chromium Content	Excess to Goal Authorized For Disposal	Sales, 9 Months
Chromite:					
Metallurgical-grade	3,200	1,758	28.6%	-	-
Chemical-grade	675	242	28.6%	-	-
Refractory-grade	850	391	-	-	-
Chromium ferroalloys:					
High-carbon ferrochromium	185	537	71.4%	-	-
Low-carbon ferrochromium	75	300	71.4%	-	-
Ferrochromium-silicon	90	57	42.9%	-	-
Chromium metal	20	4	-	-	-

8. Events, Trends, and Issues: The published price of Turkish high-chromium chromite declined from $125 to $100 per metric ton, and South African high-iron chromite price increased from a range of $40 to $42 to a range of $40 to $46 per metric ton. The price of chromium metal ranged from $3.15 to $3.75 per pound. On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Aparcheid Act of 1986, chromium was certified by the Department of State as a strategic mineral essential for the economy or defense of the United States that is unavailable in adequate quantities from reliable and secure suppliers.

Compared with that of 1986, apparent consumption declined by 11%. Chromium demand changes reflect changes or anticipated changes in the steel industry, the major consumer of chromium. It is estimated that in 1988, domestic mine production of chromium ore will be zero and U.S. apparent consumption will be about 400,000 tons.

Domestic chromium deposits are small or of low grade and are located far from consumers. Known domestic deposits are not developed for domestic use because development, extraction, beneficiation, and transportation cost exceeds the price of ore currently available from foreign sources.

Chromium releases into the environment are regulated by the Environmental Protection Agency. Workplace exposure is regulated by the Occupational Safety and Health Administration.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/ (shipping grade) 5/	Reserve Base 4/ (shipping grade) 5/
	1986	1987 e/		
United States	-	-	-	-
Brazil	315	300	9,000	10,000
Finland	500	500	19,000	32,000
India	680	700	15,000	66,000
Philippines	202	300	15,000	32,000
South Africa, Republic of	3,840	3,700	913,000	6,300,000
Turkey	660	600	5,000	80,000
Zimbabwe	600	600	19,000	830,000
Other Market Economy Countries	339	300	17,000	25,000
Albania	940	1,000	7,000	22,000
U.S.S.R.	3,250	3,300	142,000	142,000
Other Centrally Planned Economies	68	60	4,000	4,000
World Total (may be rounded)	11,394	11,400	1,165,000	7,500,000

10. World Resources: World resources total about 36 billion tons of shipping-grade chromite, sufficient to meet conceivable demand for centuries. Over 99% of these resources are in southern Africa. Although the rest of the world's resources are measured in millions of tons, they are small in comparison with those of Africa. The largest U.S. chromium resource is in the Stillwater Complex in Montana.

11. Substitutes: Substitution possibilities for chromium include: nickel for plating, iron for pigments, and boron for alloying. Magnesite may substitute for chromite in refractories.

CLAYS

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use:** In 1987, clays were produced in all States except Alaska, Delaware, Hawaii, Rhode Island, Vermont, and Wisconsin. The leading 30 firms supplied about one-half of the output and about 300 firms the remainder. Together these firms operated about 1,100 mines. Record-high production was achieved for kaolin. Estimated value of all marketable clay produced was a record high $1.2 billion. Major domestic uses for specific clays were estimated as follows: kaolin--43% paper, 7% refractories, 3% rubber; ball clay--27% dinnerware and pottery, 17% sanitaryware, 14% floor and wall tile; fire clay--48% firebricks, 10% foundry sands; bentonite--37% drilling mud, 22% foundry sand bond, 9% iron ore pelletizing; fuller's earth--75% absorbent uses, 9% insecticide dispersant; and common clay--95% construction materials.

2. **Salient Statistics--United States:** 1/

	1983	1984	1985	1986	1987 e/
Production, mine					
Kaolin	7,203	7,953	7,793	8,549	8,907
Ball clay	747	867	902	887	927
Fire clay 2/	1,043	1,145	974	592	641
Bentonite	2,887	3,438	3,195	2,813	2,609
Fuller's earth	1,912	1,899	2,059	1,910	1,956
Common clay	27,066	28,400	30,051	29,869	30,161
Total	40,858	43,702	44,974	44,620	45,201
Imports for consumption	21	32	41	38	43
Exports	2,484	2,699	2,780	2,913	3,200
Consumption, apparent	38,395	41,035	42,235	41,745	42,044
Price	$2 to $300 per ton, depending on type and quality				
Stocks, yearend 3/	Not available				
Employment: e/ Mine	2,000	2,100	2,000	2,000	2,000
Mill	9,000	9,500	9,400	9,400	9,200
Net import reliance 4/ as a percent of apparent consumption	Net exporter				

3. **Recycling:** Insignificant.

4. **Import Sources (1983-86):** United Kingdom, 43%; Mexico, 30%; Canada, 15%; other, 12%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
China clay and kaolin 5/	521.41	33¢	$2.50
Fuller's earth, not beneficiated 5/	521.51	25¢	$1.50
Wholly or partly beneficiated 5/	521.54	50¢	$3.25
Bentonite 5/	521.61	40¢	$3.25
Ball clays, not beneficiated 5/	521.71	38¢	$1.00
Wholly or partly beneficiated 5/	521.74	77¢	$2.00
Other clays, not beneficiated 5/	521.81	Free	$1.00
Wholly or partly beneficiated 5/	521.84	50¢	$2.00
Artificially activated clays	521.87	2.5% ad val.	0.25¢/lb + 30% ad val.

6. **Depletion Allowance:** Kaolin, ball clay, bentonite, fuller's earth, and fire clay 14% (Domestic), 14% (Foreign); clay used for extraction of alumina or aluminum compounds, 22% (Domestic); clay and shale used for making brick, tile, and lightweight aggregate 7.5% (Domestic), 7.5% (Foreign); clay used in making drainage and roofing tile, flower pots, and kindred products, 5% (Domestic), 5% (Foreign).

e/ Estimated.
1/ Excludes Puerto Rico.
2/ Refractory uses only.
3/ Data on stocks are not available and are assumed to be zero for apparent consumption and net import reliance calculations.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ Per long ton.

Prepared by Sarkis G. Ampian, telephone number (202) 634-1180.

7. Government Stockpile: None.

8. Events, Trends, and Issues: Total clays sold or used by domestic producers in 1987 increased 1% in tonnage and 9% in value. The clay producers operated between 60% to 95% of capacity during the year. The trend of increasing exports, spurred on by the weakening U.S. dollar, continued an annual growth begun in 1982, except for 1983, by increasing shipments about 10% to about 3.2 million tons to equal the 1980 export record-high year. Exports are traditionally limited to the higher priced premium specialty clays. It is estimated that in 1988 domestic mine production of clays will be 47 million tons and U.S. apparent consumption will be 43 million tons. The continued growth of the energy intensive clay-based industries could be slowed again by the erratic disparity in costs between fuels, such as oil and natural gas, and lower construction rates. Average prices for most clays are expected to rise slowly, reflecting higher quality requirements for the specialty clays and increasing costs associated with land acquisition, land rehabilitation, and environmental and energy factors. Greater recovery of byproducts and coproducts should occur as processing technology improves and as problems of solid waste disposal become increasingly acute.

   Further enhancement of the U.S. position as a major world supplier of high-quality clays is assured by the possession of more than adequate resources of all major types of clay coupled with the clay processing technology necessary to provide large quantities of consistent-quality clays over extended periods.

   In 1987, imports of Mexican acid-activated bentonites increased 15% over those of 1986 to about 14,000 tons. These imports adversely affected the domestic producers who are concentrated in the gulf coast area.

9. World Mine Production, Reserves, and Reserve Base: Not available.

10. World Resources: Clays are divided for commercial purposes into kaolin, ball clay, fire clay, bentonite, fuller's earth, and common clay. Resources of these types of clay are extremely large, except for lesser resources of high-grade ball clay and sodium-bentonite. Resources of kaolin in Georgia are estimated to be 5 billion to 10 billion tons.

11. Substitutes: Limited substitutes and alternatives, such as talc and whiting, are available for filler and extender applications.

COBALT

(Data in short tons of cobalt content, unless noted)

1. Domestic Production and Use: Domestic mine production ceased at the end of 1971. Most secondary cobalt is derived from recycled superalloy or cemented carbide scrap and from spent catalysts. About 13 recyclers accounted for nearly all the cobalt recycled in superalloy scrap. There were two extra-fine cobalt powder producers, one a foreign-owned company producing powder primary material and the other a domestically-controlled company producing powder from recycled materials. Nine processors were active in the production of cobalt compounds. Industrial consumers totaled about 130, with the largest in Michigan, Pennsylvania, New Jersey, and California. Superalloys, mainly for industrial and aircraft gas turbine engines, accounted for about 48% of reported consumption; driers, 14%; magnetic alloys, 10%; catalysts, 7%; and other, 21%. Total estimated value of cobalt consumed in 1987 was $120 million.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Mine			None		
Secondary	362	440	449	1,319	1,300
Imports for consumption 1/	8,611	12,655	8,854	6,144	8,000
Exports	412	336	314	316	400
Shipments from Govt. stockpile excesses 2/	(132)	(99)	(3,495)	-	-
Consumption: Reported	5,660	6,472	6,771	7,221	8,000
Apparent 1/	7,856	8,948	7,846	8,687	9,000
Price, average annual spot for cathodes, dollars per pound	5.76	10.40	11.43	7.49	6.50
Stocks, industry, yearend	4,305	5,411	5,977	4,438	4,338
Employment, mine			None		
Net import reliance 3/ as a percent of apparent consumption	95	95	94	85	86

3. Recycling: About 1,300 tons of cobalt were recycled from purchased scrap in 1987. This represented about 16% of estimated reported consumption for the year.

4. Import Sources (1983-86): Zaire, 34%; Zambia, 19%; Canada, 16%; Norway, 8% (originated in Canada); other, 23%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Unwrought metal, waste and scrap	632.20	Free	Free
Alloys, unwrought	632.86	9% ad val.	45% ad val.
Chemical compounds:			
Oxide	418.60	1.2¢/lb.	20¢/lb.
Sulfate	418.62	1.4% ad val.	6.5% ad val.
Other	418.68	4.2% ad val.	30% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

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e/ Estimated. NA Not available.

1/ Cobalt imports in 1984 included 2,706 tons of cobalt that was destined for the National Defense Stockpile but did not officially enter the stockpile; 795 tons of 1985 imports was delivered to the stockpile. To derive meaningful apparent consumption figures, the 2,706 tons and the 795 tons were treated as if they had been put into stocks in 1984 and 1985, respectively. Moreover, the 99 tons of cobalt that officially entered the stockpile in 1984 was imported in 1983 and was not used in deriving the 1984 apparent consumption figure.

2/ Data in parentheses denote stockpile acquisitions.

3/ Defined as imports - exports + adjustments for Government and industry stock changes.

4/ See page 184 for definitions.

5/ Excludes Albania.

Prepared by William S. Kirk, telephone number (202) 634-1028.

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months	Purchases, 9 Months
Cobalt	42,700	26,591	-	-	-

8. Events, Trends, and Issues: Demand for cobalt in 1987 increased slightly. As a result of significantly increased coverage of secondary cobalt consumption, calculated import reliance, which had averaged 96% from 1970 through 1985, fell to 85% in 1986 and rose to 86% in 1987. The spot price for cathode cobalt was more stable than in recent years, remaining between $6.00 and $7.00 per pound throughout the year. The electrolytic cobalt price began the year at $6.30 per pound and stayed close to that level until May, when rumors of price increases by Zaire and Zambia, the world's largest cobalt producers, were to raise prices caused the price to increase slightly. According to reports, however, the two producers were content to reaffirm the $7.00 price set in 1986 because they were convinced that that price level was best for both producers and consumers. To keep prices as close as possible to the $7.00 mark, the two producers withheld cobalt from merchants and took steps to see that consumers did not sell excess cobalt on the open market. On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Apartheid Act of 1986, cobalt was certified by the Department of State as a strategic mineral essential for the economy or defense of the United States that is unavailable in adequate quantities from reliable and secure suppliers.

Surplus market conditions are expected to prevail worldwide in 1988. Most of the surplus is in producers' stocks. It is estimated that in 1988, domestic mine production will be zero and U.S. apparent consumption will be about 9,000 tons.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States	-	-	-	950,000
Australia	970	500	25,000	100,000
Canada	2,745	3,000	50,000	285,000
Finland	1,050	1,000	25,000	37,500
New Caledonia	770	750	250,000	950,000
Philippines	100	-	150,000	440,000
Zaire	22,050	20,000	1,500,000	2,300,000
Zambia	6,350	4,000	400,000	600,000
Other Market Economy Countries	515	500	100,000	1,300,000
Albania	650	650	NA	NA
Cuba	1,550	1,500	1,150,000	2,000,000
U.S.S.R.	3,100	3,000	150,000	250,000
World Total (may be rounded)	39,850	34,900	5/3,800,000	5/9,200,000

10. World Resources: The cobalt resources of the United States are estimated to be about 1.4 million tons. Most of these resources are in Minnesota, but other important occurrences are in Alaska, California, Idaho, Missouri, Montana, and Oregon. Although large, most domestic resources are in subeconomic concentrations that will not be economically usable in the foreseeable future. The identified world cobalt resources are about 12 million tons. The vast majority of these resources are in nickel-bearing laterite deposits, with most of the rest occurring in nickel-copper sulfide deposits hosted in mafic and ultramafic rocks and in the sedimentary copper deposits of Zaire and Zambia. In addition, millions of tons of hypothetical and speculative cobalt resources exist in manganese nodules and crusts on the ocean floor.

11. Substitutes: Nickel may be substituted satisfactorily for cobalt in superalloys, but in other applications only with a loss of effectiveness. Various potential substitutes include nickel, platinum, barium or strontium ferrite and iron in magnets; tungsten, molybdenum carbide, ceramics, and nickel in machinery; nickel and ceramics in jet engines; nickel in catalysts; and copper, chromium, and manganese in paints.

COLUMBIUM

(Data in thousand pounds of columbium content, unless noted)

1. Domestic Production and Use: There has been no significant columbium mining industry since 1959, the exception being small unreported quantities of columbium-bearing concentrates produced in 1980-82. Most metal, ferrocolumbium, other alloys, and compounds were produced by seven companies with eight plants. Feed for these plants included imported concentrates, tin slags, columbium oxide, and ferrocolumbium. Consumption was mainly as ferrocolumbium by the steel industry and as columbium alloys and metal by the aerospace industry, with plants located in the Eastern and Midwestern United States, California, and Washington. Total estimated value of shipments of domestically produced ferrocolumbium, nickel columbium, and metal was about $30 million. End uses as metal and alloys in fabricated form were: construction, 44%; transportation, 24%; oil and gas industries, 13%; machinery, 11%; and other, 8%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, mine			None		
Imports for consumption:					
Concentrates, tin slags, and other 1/	W	W	W	W	W
Ferrocolumbium e/	2,539	4,343	4,699	4,332	4,100
Exports, concentrate, metal, alloys, waste, and scrap e/	78	80	77	72	80
Shipments from Govt. stockpile excesses	--	-	2/(213)	-	-
Consumption, reported:					
Raw material e/	1,900	2,600	2,000	W	NA
Ferrocolumbium 3/	4,318	5,399	5,968	4,995	4,600
Consumption, apparent	5,750	7,670	7,550	7,060	7,000
Price: Columbite, dollars per pound 4/	6.00	5.50	4.25	3.67	2.25
Pyrochlore, dollars per pound 5/	3.25	3.25	3.22	2.60	2.60
Stocks, industry, processor and consumer, yearend	W	W	W	W	W
Employment, processor e/	500	500	500	450	450
Net import reliance 6/ as a percent of apparent consumption	100	100	100	100	100

3. Recycling: Insignificant.

4. Import Sources (1983-86): Brazil, 74%; Canada, 15%; Thailand, 3%; other, 8%.

5. Tariff: In 1987, columbium oxide imported from Brazil was duty free.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Columbium oxide	423.0050	3.7% ad val.	25.0% ad val.
Columbium carbide	423.0094	3.7% ad val.	25.0% ad val.
Columbium concentrate	601.2100	Free	Free
Ferrocolumbium	606.5300	5.0% ad val.	25.0% ad val.
Columbium, unwrought:			
Metal, waste, and scrap	628.1500	3.7% ad val.	25.0% ad val.
Alloys	628.1700	4.9% ad val.	25.0% ad val.
Columbium, wrought	628.2000	5.5% ad val.	45.0% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Metal, alloys, synthetic concentrates, and columbium oxide.
2/ Data in parentheses denote stockpile acquisitions.
3/ Includes nickel columbium and a small quantity of other columbium materials; contains estimates.
4/ Average value, contained pentoxides for material having a Cb_2O_5 to Ta_2O_5 ratio of 10 to 1.
5/ Average value, contained pentoxide.
6/ Defined as imports - exports + adjustments for Government and industry stock changes.
7/ See page 184 for definitions.
8/ Excludes Centrally Planned Economies.

Prepared by Larry D. Cunningham, telephone number (202) 634-1029.

7. **Government Stockpile:** In addition to quantities shown below, the stockpile contains 869,000 pounds in nonstockpile-grade columbium concentrate and 333,000 pounds in nonstockpile-grade ferrocolumbium.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Columbium:				
Carbide powder	100	21	-	-
Concentrate	5,600	1,150	-	-
Ferrocolumbium	-	598	-	-
Metal	-	45	-	-

8. **Events, Trends, and Issues:** First half overall reported consumption of columbium was down by more than 10% from that of the same period in 1986. For the same period, demand for columbium in superalloys was down by about 30%, with that portion used in the form of nickel columbium down by over 50%. Imports of columbium concentrates rose substantially, the bulk of imports continuing to come from Canada, while imports of ferrocolumbium continued to decline. The published price for Canadian pyrochlore was being quoted in the fourth quarter at $2.60 per pound of contained pentoxide, and the spot price for columbite concentrates remained at $2.00 to $2.50 per pound of contained columbium and tantalum pentoxides. Also, the published spot price for steelmaking-grade ferrocolumbium continued unchanged at $5.66 per pound of contained columbium and the quoted price for high-purity ferrocolumbium remained at $17.00 to $17.50 per pound of contained columbium. It is estimated that in 1988 domestic mine production of columbium will be zero, and U.S. apparent consumption will be about 7 million pounds.

There are no known uncontrollable health hazards connected with production or fabrication of columbium metals and compounds. Fumes, gases, dust, and low-level radiation generated by columbium-processing plants can be controlled by modern technology.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production e/		Reserves 7/	Reserve Base 7/
	1986	1987		
United States	-	-	-	Negligible
Brazil	27,780	28,000	7,100,000	8,000,000
Canada	5,160	4,300	270,000	700,000
Nigeria	12	20	140,000	200,000
Zaire	70	70	70,000	200,000
Other Market Economy Countries	125	130	14,000	19,000
Centrally Planned Economies	NA	NA	NA	NA
World Total (may be rounded) 8/	33,147	33,000	7,600,000	9,100,000

10. **World Resources:** Most of the world's identified resources of columbium lie outside the United States and occur mainly as pyrochlore in carbonatite deposits. On a worldwide basis, resources are more than adequate to supply projected needs. The United States has approximately 800 million pounds of columbium resources located in identified deposits, which were considered uneconomic at 1987 prices for columbium.

11. **Substitutes:** The following materials can be substituted for columbium, but a performance or cost penalty may ensue: Vanadium and molybdenum in high-strength low-alloy steels; tantalum and titanium in stainless and high-strength steel and superalloys; and molybdenum, tungsten, tantalum, and ceramics in high-temperature applications.

COPPER

(Data in thousand metric tons of copper content, unless noted)

1. Domestic Production and Use: Domestic mine production in 1987 was about 1.3 million tons, valued at $2.2 billion. The principal mining States, in descending order, were Arizona, New Mexico, Utah, Michigan and Montana, but seven other States also yielded copper. Fifteen mines accounted for more than 95% of mine production. Eight primary and seven secondary smelters, seven primary and seven secondary refineries and ten electrowinning plants were operating at yearend. Copper was consumed at about 20 wire rod mills, 35 primary brass mills and 1,000 foundries, chemical plants and miscellaneous manufacturers. Copper consumption in 1987, by industrial sector 1/ was: building construction, 42%; electrical and electronic products, 24%; industrial machinery and equipment, 13%; transportation, 11%; and consumer and general products, 10%.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production: Mine	1,038	1,103	1,106	1,147	1,270
Refinery: Primary 2/	1,182	1,165	1,057	1,073	1,130
Secondary 3/	402	325	377	406	430
Copper from old scrap, all sources	449	461	503	479	520
Imports for consumption: Ores and Concentrates	91	11	3	4	2
Refined	460	445	378	502	460
All imports	675	552	444	598	560
Exports: Ores and Concentrates	50	61	116	174	120
Refined	81	91	38	12	10
All exports	239	317	435	442	360
Consumption: Refined, reported	1,804	2,123	1,976	2,102	2,160
Apparent, total 4/	2,013	2,107	2,144	2,136	2,190
Price, average, cents per pound:					
Domestic producer cathode	76.5	66.8	67.0	66.1	80.0
London Metal Exchange, high grade	72.1	62.4	64.3	62.3	78.0
Stocks, yearend, refined 5/	672	544	300	205	120
Employment, mine and mill	14,700	12,461	9,854	10,154	11,500
Net import reliance 6/ as a percent of apparent consumption	19	23	28	27	25

3. Recycling: Old scrap, converted to refined metal and alloys, provided 520,000 tons of copper, or 24% of apparent consumption. Purchased new scrap, derived from fabricating operations, yielded 650,000 tons of contained copper. Of the total copper recovered from scrap, smelters and refiners recovered 47%, brass mills, 45%, and miscellaneous manufacturers, foundries and chemical plants, 8%. About 37% was recovered as refined copper. Seventy-five percent of the copper contained in new scrap was recovered at brass mills.

4. Import Sources (1983-86): Chile, 35%; Canada, 34%; Peru, 8%; Mexico, Zaire, Zambia, each 5%; other 8%. Refined imports accounted for 79% of total imports; Chile and Canada were the sources of 71% of refined imports.

5. Tariff: Of the major import sources in 1987, under special tariff rates, certain articles from Chile, Mexico, Peru, Zaire and Zambia were duty free.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Black copper, blister, anode	612.03	1.0% on the value of copper content	6.0% ad val.
Refined, unwrought	612.06	1.0% ad val.	6.0% ad val.
Waste and scrap	612.10	Free	6.0% ad val.

e/ Estimated.
1/ Some electrical components included in each industrial sector.
2/ From domestic and imported materials.
3/ From new and old scrap, at primary and secondary refineries.
4/ Defined as primary refined production + copper refined from old scrap + copper recovered in alloys from old scrap + refined imports - refined exports ± changes in refined stocks.
5/ Held by industry and by Commodity Exchange Inc.; excludes Government stocks.
6/ Defined as imports - exports + adjustments for Government and industry stock changes.
7/ See page 184 for definitions.

Prepared by Janice L. W. Jolly and Daniel Edelstein, telephone number (202) 634-1053.

6. **Depletion Allowance:** 15% (Domestic), 14% (Foreign).

7. **Government Stockpile:**

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Copper	907	20	-	-

In addition to the quantity of refined copper shown above, the stockpile contained 6,124 tons of copper in brass and 548 tons of nonstockpile grade material.

8. **Events, Trends, and Issues:** Copper mine production in the United States increased in 1987 to the highest level since 1981 as a result of increased capacity at several operating mines and renewed activity at the Bingham Canyon Mine. All copper mining companies were profitable during the year as a consequence of lower operating costs and higher copper prices. Productivity improvements, and financial arrangements that involved changes in ownership and copper segment spin-offs continued during the year. One company, after being spun-off, initiated construction of a new flash smelter with increased capacity. Two smelters closed during the year, including one with a capacity of 136,000 tons of blister per year, which closed permanently in January as a result of a decision not to bring it into compliance with environmental regulations. A third smelter was reactivated in conjunction with the Bingham Canyon Mine. As a result of the improved market and renewed speculative influences, copper prices were at the highest levels since 1980. A flurry of activity surrounded the discovery of ceramic superconducting materials composed of copper oxides in conjunction with various other materials, that operate at markedly higher temperatures than do conventional superconducting materials.

In response to an improved economic environment, refined copper consumption increased in 1987, assuring further drawdown of copper inventories and a tight market supply through much of the year. Compounding the domestic tightness of copper was a record level of scrap exports. U.S. net import reliance declined slightly despite a continued high level of refined imports. It is estimated that in 1988, U.S. apparent consumption of copper will be 2.2 million tons and that domestic mine production will be nearly 1.4 million tons.

9. **World Mine Production, Reserves, and Reserve Base:**

	Production			
	1986	1987 e/	Reserves 7/	Reserve Base 7/
United States	1,147	1,270	57,000	90,000
Australia	239	230	8,000	41,000
Canada	768	740	17,000	23,000
Chile	1,386	1,420	79,000	120,000
Peru	397	450	12,000	32,000
Philippines	223	220	12,000	18,000
Zaire	563	560	26,000	30,000
Zambia	450	435	16,000	34,000
Other Market Economy Countries	1,456	1,460	60,000	100,000
Poland	431	435	10,000	15,000
U.S.S.R. e/	620	640	37,000	54,000
Other Centrally Planned Economies e/	476	480	6,000	9,000
World Total (may be rounded)	8,156	8,340	340,000	570,000

Bureau of Mines' estimates of Zambian reserve data were lowered in 1987 to reflect changes in mining plans, as reported in company annual reports.

10. **World Resources:** Land-based resources are estimated at 1.6 billion tons of copper, and resources in deep sea nodules are estimated at 0.7 billion tons. About 85% of the land-based resource is located in the market economy countries.

11. **Substitutes:** Other materials may substitute for copper in some applications, such as aluminum in electrical equipment, automobile radiators, and refrigerator tubing, titanium and steel in heat exchangers, steel in artillery shell casings, optical fiber in telecommunications cable, and plastics in water pipe and plumbing fixtures.

DIAMOND (INDUSTRIAL)

(Data in million carats, unless noted)

1. **Domestic Production and Use**: Synthetic diamond production, exports, and imports established record-high levels. All industrial diamond produced domestically was synthetic grit and powder in sizes suitable for use in saws, machine tools, drill bits, grinding wheels, and grinding and polishing, and was the output of four firms, one each in Michigan, New Jersey, Ohio, and Utah. Four firms recovered and sold industrial diamond as the principal product. About 35 firms recovered industrial diamond in secondary operations and the majority of these diamonds were either credited to the clients' account or reset in their bits or tools. Major uses of all industrial diamond were: machinery, 27%; mineral services, 18%; stone and ceramic products, 17%; abrasives, 16%; contract construction, 13%; transportation equipment, 6%; and other, 3%. The mineral services industry, primarily drilling, accounted for 85% of stone consumption.

2. **Salient Statistics--United States**: 1/

	1983	1984	1985	1986	1987 e/
Bort, grit, and powder and dust, natural and synthetic:					
Production: Manufactured diamond	69.0	76.0	76.0	80.0	W
Secondary e/	1.2	1.5	1.0	3.1	3.0
Imports for consumption	18.8	35.2	36.4	37.1	44.5
Exports and reexports 2/	42.3	48.0	51.6	51.2	52.6
In manufactured products e/	0.5	0.5	0.6	0.6	0.6
Sales of Govt. stockpile excesses	0.2	-	-	-	-
Consumption, apparent	46.4	64.2	61.2	68.4	W
Price, value of imports, dollars per carat	1.49	1.33	1.27	1.25	1.21
Net import reliance 3/ as a percent of apparent consumption		Net exporter			
Stones, natural:					
Production: Mine			None		
Secondary e/ 4/	0.6	0.7	0.5	1.5	0.3
Imports for consumption	6.1	8.3	9.4	8.9	6.0
Exports and reexports 2/	3.2	3.3	3.3	3.6	3.1
In manufactured products e/	0.3	0.5	0.5	0.5	0.5
Sales from Govt. stockpile excesses 5/	1.0	1.5	1.5	2.0	2.0
Consumption, apparent	3.2	5.2	6.1	6.3	2.7
Price, value of imports, dollars per carat	9.98	8.03	8.52	7.23	11.45
Net import reliance 3/ as a percent of apparent consumption:	81	87	92	76	89

3. **Recycling**: About 3.3 million carats were salvaged in secondary production from salvage stone, sludge, and swarf.

4. **Import Sources (1983-86)**: Bort, grit, and powder and dust, natural and synthetic: Ireland, 64%; Japan, 9%; United Kingdom, 5%; Republic of South Africa, 5%; other, 17%. Stone, natural: Republic of South Africa, 53%; United Kingdom, 16%; Ireland, 11%; Belgium-Luxembourg, 6%; other, 14%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Synthetic diamond, other	520.21	3.0% ad val.	30.0% ad val.
Miners' diamond, synthetic/natural	520.19,520.23	Free	Free
Crushing bort	520.27	Free	Free
Powder or dust, synthetic/natural	520.20,520.28	Free	Free
Other: Not advanced in condition	520.29	Free	Free

e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Industry stocks and employment were unknown.
2/ Excludes diamonds in manufactured abrasive products.
3/ Defined as imports - exports including reexports + adjustments for Government and industry stock changes.
4/ Salvaged industrial diamond stones were originally imported.
5/ Diamond stones sold from the Govt. stockpile excesses were apparently exported to Belgium as near gem-quality diamond; consequently, they were excluded from the apparent consumption and net import reliance calculations.
6/ Natural industrial diamond only.
7/ See page 184 for definitions.

Prepared by Gordon T. Austin, telephone number (202) 634-1206.

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: Excess diamond stones were used as payment materials for the ferroalloys upgrading program.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Crushing bort	22.0	22.0	-	-
Industrial stones	7.7	9.5	1.8	1.5

8. Events, Trends, and Issues: Diamond exploration continued in Alaska, Michigan, Minnesota, Wisconsin, Colorado, and Wyoming in 1987. The proposed diamond project in Arkansas remained under study by the State. The Argyle opencast lamproite pipe mine in Western Australia produced approximately 33 million carats. Domestic diamond synthesis in 1986 was more than adequate for materials up to 16 mesh. However, synthesis in the United States of larger industrial diamond was not commercial; hence, the United States was dependent upon imported stones or disposal of Government stockpile excesses. The price of 16 mesh and smaller diamond has decreased as a result of competition between domestic synthetic diamond and imported synthetic and natural diamond. The firm located in Michigan that produced grit and polycrystalline diamond was purchased and disassembled during the year. The prices of new imported stones increased significantly for the first time since 1980-81. The impact of new synthetic diamond film technology has yet to be determined.

On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Apartheid Act of 1986, natural industrial diamonds were certified by the U.S. Department of State as strategic minerals essential for the economy or defense of the United States that are unavailable in adequate quantities from reliable and secure suppliers.

9. World Mine Production, Reserves, and Reserve Base: 6/

	Mine Production		Reserves e/ 7/	Reserve Base e/ 7/
	1986	1987 e/		
United States	-	-	-	Unknown
Australia	16.1	18.2	500	900
Botswana	3.5	3.7	125	200
Brazil	0.3	.3	5	15
South Africa, Republic of	5.7	6.2	70	150
Zaire	18.6	19.0	150	350
Other Market Economy Countries	1.3	1.3	40	65
China	0.8	0.8	10	20
U.S.S.R.	6.4	6.4	80	200
World Total	52.7	55.9	980	1,900

10. World Resources: The potential to discover diamond resources in the United States has improved. However, evaluation of deposits already discovered will take several more years. Technology has been developed to synthesize diamond for industrial use worldwide in the range of sizes of crushing bort, powder, and dust. World resources of natural industrial diamond in the stone-size range are unknown.

11. Substitutes: Competitive materials were cubic boron nitride, fused aluminum oxide, and silicon carbide as manufactured abrasive materials; and garnet, emery, and corundum as natural abrasive minerals. Synthesized polycrystalline diamond was competitive with natural stones in some applications. Research continued on additional uses of synthetic polycrystalline compacts and shapes as substitutes for stones.

DIATOMITE

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use**: The estimated value of processed diatomite, f.o.b. plant, was $135 million in 1987. Seven companies with eleven processing facilities in four States produced diatomite. California was the principal producing State and accounted for more than 50% of production. End uses of diatomite were: filter aid, 67%; fillers, 17%; and other, 16%.

2. **Salient Statistics--United States**:

	1983	1984	1985	1986	1987 e/
Production 1/	619	627	635	628	665
Imports for consumption	2/	2/	5	1	7
Exports	146	127	120	131	140
Consumption, apparent	473	500	520	498	532
Price, average value, dollars per ton, f.o.b. plant	185.00	193.00	200.00	204.00	203.00
Stocks, producer, yearend	36	36	36	36	36
Employment, mine and plant e/	900	900	900	1,000	1,000
Net import reliance 3/ as a percent of apparent consumption		Net exporter			

3. **Recycling**: None.

4. **Import Sources (1983-86)**: Taiwan, 74%; Mexico, 13%; other, 13%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude or processed	522.11	Free	Free

6. **Depletion Allowance**: 14% (Domestic), 14% (Foreign).

7. **Government Stockpile**: None.

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e/ Estimated. NA Not available.
1/ Processed ore sold and used by producers.
2/ Less than 500 tons.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions.
5/ Estimated diatomite content of moler production.

Prepared by Arthur C. Meisinger, telephone number (202) 634-1185.

8. **Events, Trends, and Issues:** The United States remained the largest producer and consumer of diatomite and exported processed diatomite to more than 50 countries, primarily for filtration use. Two new mine and plant operations, onstream in late 1986, increased domestic production capacity during 1987.

All domestic mining is by open pit and conflicting land-use problems exist. Control of dust in mining is adequate owing to the high moisture content of the crude ore. Almost all processing is enclosed to permit effective control of silica dust.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States	1/ 628	1/ 665	250,000	500,000
Brazil	20	20		2,000
Denmark	5/ 91	5/ 90		NA
France	265	265	Other	2,000
Germany, Federal Republic of	50	50	Countries	NA
Iceland	26	25	550,000	2,000
Korea, Republic of	55	55		NA
Mexico	50	50		NA
Spain	88	90		NA
Other Market Economy Countries	92	90		NA
Centrally Planned Economies	607	610		NA
World Total (rounded)	1,970	2,000	800,000	2,000,000

10. **World Resources:** World resources of crude diatomite are adequate for the foreseeable future, but the need for diatomite near markets encourages development of new sources for the material.

11. **Substitutes:** Many alternate materials can be substituted for diatomite; however, the unique properties of diatomite assure a continuing acceptance for many applications. Expanded perlite, asbestos, and silica sand compete for filtration purposes although, in most instances, diatomite is a superior material. Alternate filler materials include talc, ground silica sand, ground mica, clay, perlite, vermiculite, and ground limestone. For thermal insulation, materials such as brick, clay, asbestos, mineral wool, expanded perlite, and exfoliated vermiculite can be used.

FELDSPAR

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use**: U.S. feldspar production in 1987 had an estimated value of $27 million. The three largest producers accounted for about 70% of the output, and the next three jointly supplied 20%. North Carolina provided 70% of the 1987 output, and five other States contributed smaller quantities.

   Production of lithium ores and mica yielded moderate quantities of byproduct or coproduct feldspar and feldspar-silica mixtures in 1987, and feldspar processors reported coproduct recovery of mica and silica sand.

   Feldspar is ground for use in industry to about 20 mesh for glassmaking and to 200 mesh or finer for most ceramic and filler applications. Major shipments went to Georgia, Illinois, Indiana, New Jersey, Ohio, Pennsylvania, and Texas, with lesser amounts going to at least 24 other States and foreign destinations, especially Canada and Mexico. In ceramics and glass, feldspar functions principally as a flux. Estimated 1987 end-use distribution of domestic feldspar was: glass, 54% and pottery, 46%.

2. **Salient Statistics—United States**:

	1983	1984	1985	1986	1987 e/
Production, marketable	710	710	700	735	730
Imports for consumption	1/	1/	1	1	5
Exports	9	10	9	12	7
Consumption, apparent	701	700	692	724	728
Price, average, dollars per ton	31.70	33.10	32.60	35.51	37.00
Stocks, producer, yearend 2/	Not available				
Employment, mine and preparation plant	450	450	450	450	450
Net import reliance 3/ as a percent of apparent consumption	Net exporter				

3. **Recycling**: Insignificant.

4. **Import Sources (1983-86)**: Mexico, 51%; Venezuela, 43%; Canada, 2%; other, 4%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude	522.31	Free	50¢/long ton
Ground	522.41	2.8% ad val.	30% ad val.

6. **Depletion Allowance**: 14% (Domestic), 14% (Foreign).

7. **Government Stockpile**: None.

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e/ Estimated.
1/ Less than 1/2 unit.
2/ Change in stocks assumed to be zero for apparent consumption and net import reliance calculations.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions.

Prepared by Michael J. Potter, telephone number (202) 634-1180.

8. **Events, Trends, and Issues:** U.S. mine production of feldspar was slightly higher than the average of the preceding decade (1977-86). Fewer housing starts compared with those of 1986 resulted in reduced feldspar usage in plumbing fixtures, tile, and glass fiber for insulation. Imports of nepheline syenite in 1987 were an estimated 305,000 tons, or slightly higher than those of 1986. With the glass and ceramics industries showing signs of maturity, producers continued looking to other markets such as the use of feldspar as a filler and extender in plastics and coatings, and to new markets and products.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production e/		Reserves and Reserve Base 4/
	1986	1987	
United States	735	730	
Brazil	132	140	
France	220	230	Large in the United States and assumed to large in other countries.
Germany, Federal Republic of	353	360	
Italy	1,364	1,370	
Mexico	110	120	
Spain	149	160	
Other Market Economy Countries	1,014	1,030	
U.S.S.R. e/	370	370	
Other Centrally Planned Economies	183	190	
World Total	4,630	4,700	

10. **World Resources:** Identified and hypothetical resources of feldspar are more than adequate to meet anticipated world demands. Quantitative data on hypothetical resources of feldspar existing in granites, pegmatites, and feldspathic sands have not been compiled. There is ample geologic evidence that resources are immense although not always conveniently accessible from the principal centers of consumption.

11. **Substitutes:** Feldspar can be replaced in some of its end uses by feldspar-silica mixtures, clays, talc, pyrophyllite, spodumene, or electric-furnace slag. Imported nepheline syenite, however, was the major alternate material.

FLUORSPAR

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: Four companies in three States shipped an estimated 80,000 tons of fluorspar in 1987. Two producers in southern Illinois accounted for over 90% of domestic output. Small shipments from Nevada and Texas accounted for the remainder. Zinc concentrate was a coproduct of fluorspar mining and milling in Illinois.

Approximately 70% of the fluorspar consumed in the United States in 1987 went into the manufacture of hydrofluoric acid (HF), a key ingredient in the aluminum, fluorochemical, and uranium industries. About 25% was consumed by steelmakers. The remainder was consumed in glass manufacture, welding rod coatings, enamels, and other end uses or products.

Supplementing domestic supplies of fluorine were about 74,000 tons of fluosilicic acid (FSA) (equivalent to 130,000 tons of fluorspar) recovered from 13 phosphoric acid plants processing phosphate rock. The sole HF operation that also recovered FSA was closed in 1987. FSA was used primarily in water fluoridation, either directly or after being processed to sodium silicofluoride, and by the aluminum industry.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Finished (all grades) e/ 1/	61	72	66	78	80
Fluorspar equivalent from phosphate rock	117	118	132	100	130
Imports for consumption:					
Acid-spar	385	521	432	429	430
Met-spar	68	182	121	123	120
Fluorspar equivalent from hydrofluoric acid plus cryolite	146	199	177	186	230
Exports, ceramic and acid grades	9	12	10	16	3
Consumption: Apparent 2/	614	742	683	571	647
Reported: Acid-spar	382	547	422	444	450
Met-spar 3/	182	206	145	134	150
Price, yearend: 4/ Acid-spar, $/ton	180	173	173	173	173
Met-spar, $/ton	125	125	125	125	125
Stocks, yearend, consumer	99	120	47	90	70
Employment, mine and mill e/	300	300	300	200	200
Net import reliance 5/ as a percent of apparent consumption	90	90	90	86	88

3. Recycling: Increasing quantities of fluorides were being recycled annually in the aluminum industry. There is no recycling in other consuming industries.

4. Import Sources (1983-86): Mexico, 51%; Republic of South Africa, 30%; other, 19%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Acid grade (more than 97% CaF_2)	522.21	$2.10/long ton	$5.60/long ton
Metallurgical grade (less than 97% CaF_2)	522.24	13.5% ad val.	13.5% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Shipments.
2/ Excludes fluorspar equivalent of fluosilicic acid, hydrofluoric acid, and cryolite.
3/ Includes fluorspar briquets.
4/ Fluorspar prices, f.o.b. Illinois, are quotations from Engineering and Mining Journal.
5/ Defined as imports - exports + adjustments for Government and industry stock changes.
6/ See page 184 for definitions.
7/ Measured as 100% calcium fluoride.
8/ Includes the United States.

Prepared by Lawrence Pelham, telephone number (202) 634-1177.

7. Government Stockpile: In addition to the quantity shown below, the stockpile contains 899 tons of nonstockpile acid-grade material and 116,863 tons of nonstockpile metallurgical-grade material.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Acid grade	1,400	895	-	-
Metallurgical grade	1,700	295	-	-

8. Events, Trends, and Issues: Domestic production was essentially unchanged from that of 1986. For all but two active mines in southern Illinois, U.S. fluorspar deposits remained uncompetitive with those of foreign producers because of the current prices of imported fluorspar and the cost of freight between fluorspar deposits in Western States and the nearest major consumers. Financial transactions and development work were conducted toward reopening dormant mines and mills in the Illinois/Kentucky fluorspar district. A new mine and mill began operating in Newfoundland, Canada. The operation was expected to become a U.S. supplier.

An international agreement was reached to freeze and later reduce consumption of chlorofluorocarbons that are believed by many scientists to attack the ozone layer in the upper atmosphere. The potential impact on the demand for fluorspar was uncertain but resulted in an expensive search for substitutes for currently used chlorofluorocarbons.

Fluorspar demand, as measured by apparent consumption, increased 13%, with consumption by the aluminum, chemical, and steel industries showing some improvement. It is estimated that in 1988, domestic mine production of fluorspar will be unchanged and U.S. apparent consumption will be 650,000 tons. Estimated fluosilicic acid production in 1988 is expected to be unchanged.

The average value of domestically produced fluorspar was withheld to avoid disclosing company proprietary data. The average reported value of fluorspar entering U.S. ports was $90 per ton for acid grade and $55 for fluorspar containing not more than 97% calcium fluoride.

9. World Mine Production, Reserves, and Reserve Base:

	Production		Reserves 6/ 7/	Reserve Base 6/ 7/
	1986	1987 e/		
United States	e/78	80	W	11,000
France	259	260	7,000	10,000
Italy	160	160	7,000	8,000
Kenya	66	70	2,000	3,000
Mexico	845	840	20,000	24,000
South Africa, Republic of	375	380	32,000	40,000
Spain	331	300	7,000	9,000
Thailand	281	280	1,000	2,000
United Kingdom	187	180	2,000	3,000
Other Market Economy Countries	352	350	8/10,000	10,000
China	716	720	19,000	25,000
Mongolia e/	816	820	55,000	65,000
U.S.S.R. e/	617	620	68,000	104,000
Other Centrally Planned Economies	284	280	13,000	20,000
World Total (may be rounded)	5,367	5,340	243,000	334,000

10. World Resources: Identified world fluorspar resources amount to approximately 400 million tons of contained fluorspar. Resources of equivalent fluorspar from domestic phosphate rock are approximately 35 million tons. World resources of fluorspar from phosphate rock are estimated at 360 million tons.

11. Substitutes: Olivine and/or dolomitic limestone were used as substitute fluxes for fluorspar. Gaseous hydrocarbons and carbon dioxide have been substituted for chlorofluorocarbons as aerosol propellants.

GALLIUM

(Data in kilograms of gallium content, unless noted)

1. **Domestic Production and Use**: Primary gallium was recovered by one domestic company from mined material near St. George, UT. Another company in Quapaw, OK, recovered and refined gallium from imported material and scrap. About 95% of the gallium consumed in the United States was in the form of compounds, primarily gallium arsenide, to produce semiconductors, light emitting diodes, laser diodes, and other electronic devices. These devices were incorporated into computers, fiber optics communications systems, and satellites.

2. **Salient Statistics--United States**:

	1983	1984	1985	1986	1987 e/
Production, refinery e/	-	-	-	1/750	1,000
Imports for consumption	7,294	9,669	7,961	17,202	14,000
Exports		Not available			
Consumption: Reported	6,425	7,060	7,396	16,043	15,000
Apparent		Not available			
Price, dollars per kilogram	525	525	525	525	525
Stocks, producer, yearend		Not available			
Employment, refinery e/	20	20	20	20	20
Net import reliance 2/ as a percent of apparent consumption		Not available			

3. **Recycling**: Old scrap, none. Substantial quantities of new scrap generated in the manufacture of solid state semiconductor devices were reprocessed.

4. **Import Sources (1983-86)**: Switzerland, 43%; France, 31%; Federal Republic of Germany, 16%; United Kingdom, 4%; other 6%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Gallium compounds	423.00	3.7% ad val.	25.0% ad val.
Gallium metal	632.24	3.7% ad val.	25.0% ad val.

6. **Depletion Allowance**: Not applicable.

7. **Government Stockpile**: None.

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e/ Estimated.
1/ Reported figure.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.

Prepared by Deborah A. Kramer, telephone number (202) 634-1083.

8. Events, Trends, and Issues: Domestic gallium demand remained strong as manufacturers of gallium arsenide-based integrated circuits developed new products for commercial applications. Most of the gallium consumed in the United States was supplied by imported material. The sole domestic gallium producer closed its mine and mill for at least 4 months, beginning September 1, to complete repairs and improvements to the refinery.

   With the sustained interest in gallium arsenide technology, several companies announced plans to construct new or expand current gallium recovery and refinery capacities. A gallium producer, based in France, planned to construct a 45,000-kilogram-per-year gallium extraction plant in Australia and a 45,000-kilogram-per-year gallium purification plant in Freeport, TX. Both plants were scheduled to be completed by 1988. A Swiss-based firm planned to construct a 15,000-kilogram-per-year gallium extraction plant in Gramercy, LA, by the end of 1987. The first 2 years of production was scheduled to be shipped to Italy for use in a solar neutrino capture experiment. Construction of a 10,000-kilogram-per-year gallium extraction plant in France was planned by 1989 to recover gallium from zinc residues. By 1988, extraction capacity of a primary gallium plant in Hungary was planned to be doubled to 8,000 kilograms per year, and the gallium producer in Czechoslovakia planned to double its gallium extraction capacity to 4,000 kilograms per year by 1990. A gallium producer announced that it would close one extraction plant in Lunen, the Federal Republic of Germany, in 1988, but planned to increase annual capacity at its Schwandorf plant to 15,000 kilograms by the end of 1987. A Canadian-based firm began operating a 4,000-kilogram-per-year gallium arsenide scrap recovery facility in March in Ontario, and planned to construct a 4,000-kilogram-per-year primary gallium recovery facility in Quebec by 1988.

9. World Mine Production, Reserves, and Reserve Base: Data on world production of gallium were unavailable because data on the output of the few producers was considered to be proprietary. However, in 1987 world primary production was estimated to be about 50,000 kilograms with France, the Federal Republic of Germany, and Japan as the largest producing countries. Countries with smaller output were China, Czechoslovakia, Hungary, and the United States.

   Gallium occurs in very small concentrations in many rocks and ores of other metals. Most of it was produced as a byproduct of treating bauxite, and the remainder was produced from residues from zinc processing. Significant reserves of gallium also occur in oxide minerals derived from surficial weathering of zinc-lead-copper ores.

   Only part of the gallium present in bauxite and zinc ores was recoverable, and the factors controlling the recovery were proprietary. Therefore, a meaningful estimate of current reserves could not be made. The world bauxite reserve base is so large that much of it will not be mined for many decades; hence, most of the gallium in it can be considered to have only long-term availability.

10. World Resources: On the assumption that the average content of gallium in bauxite is 50 parts per million (ppm), about 2 million kilograms of this metal are present in the bauxite reserves in Arkansas. The gallium in U.S. bauxite resources, which are mainly subeconomic deposits, is approximately 15 million kilograms. Some domestic zinc ores contain as much as 50 ppm gallium and, as such, could be a significant resource. World resources of gallium in bauxite are estimated to exceed 1 billion kilograms, and a considerable quantity could be present in world zinc reserves. The foregoing estimates apply to total gallium content; only a small percentage of this metal in bauxite and zinc ores is economically recoverable.

11. Substitutes: Liquid crystals made from organic compounds are used in visual display panels as substitutes for light-emitting diodes. Silicon and indium phosphide are alternate materials for gallium in many semiconductor applications.

GARNET, INDUSTRIAL 1/

(Data in short tons of garnet, unless noted)

1. **Domestic Production and Use**: Garnet was produced in 1987 by four firms, two in New York, one each in Idaho, and Maine. Output of refined material was valued at $8.7 million. The end uses for garnet were: abrasives in transport manufacturing, 50%; filtration media, 30%; finishing wood furniture, 10%; electronic components, 7%; and ceramics and glass, 3%.

2. **Salient Statistics--United States**:

	1983	1984	1985	1986	1987 e/
Production	29,767	29,647	36,727	32,296	41,900
Sold by producers	30,300	27,672	30,634	31,856	43,700
Imports for consumption e/	-	-	-	400	3,000
Exports e/	3,200	3,400	3,200	5,500	5,500
Consumption, apparent	27,100	24,272	27,434	26,756	41,200
Price, range of value, dollars per ton:	120-1,200	70-1,200	70-1,200	10-1,200	45-2,000
Stocks e/	6,401	8,376	14,469	14,000	7,725
Employment, mine and mill	130	130	120	130	130
Net import reliance 2/ as a percent of apparent consumption	Net exporter				

3. **Recycling**: None.

4. **Import Sources (1983-86)**: Australia, 100%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Other abrasives, emery, corundum, pumice, flint, rottenstone, garnet, in grains or ground, pulverized, or refined	519.3760	0.3¢/lb	1.0¢/lb
Papers, cloths, etc., wholly or partly covered with abrasives, artificial or natural, in sheets, strips, belts, etc.	519.5100	2.5% ad val.	20% ad val.
Abrasive articles, n.s.p.f, other, of emery or garnet	519.9100	3.7% ad val.	20% ad val.

6. **Depletion Allowance**: 14% (Domestic), 14% (Foreign).

7. **Government Stockpile**: None.

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e/ Estimated. n.s.p.f. not specifically provided for.
1/ Excludes gem and synthetic garnet.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.

Prepared by Gordon T. Austin, telephone number (202) 634-1206.

8. Events, Trends, and Issues: The environmental effects of garnet mining were minor. Tailings from the quarrying operations in New York were used within the quarry property for fill and road maintenance. In Idaho, the land was restored after placer mining the garnet-bearing gravel. Tailings from the quarrying operations in Maine were sold as a utility grit for nonskid surfaces and as a one pass silica-free airblasting medium.

   A facility for recycling/reclaiming garnet was completed in November and will begin marketing material in 1988. Imports from Australia continued to grow but do not appear to have had a negative impact on the domestic filtration media and airblasting medium markets.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States	32,296	41,900	5,000,000	25,000,000
Australia	6,330	14,000	1,000,000	7,000,000
India	6,500	6,500	50,000	10,000,000
Other Market Economy Countries	100	600	1,520,000	10,000,000
China	3,000	3,000	Moderate to Large	Moderate to Large
U.S.S.R.	1,000	1,000	500,000	10,000,000
World Total	49,726	67,000	Moderate	Large

10. World Resources: Garnets occur in a large variety of rocks all over the world, more particularly in gneisses and schists. They also occur as contact-metamorphic deposits in crystalline limestones, pegmatites, and serpentinites, and in high-temperature intrusive contacts and vein deposits. Alluvial garnet is also a coproduct with many heavy mineral sand and gravel deposits in the world. Large domestic resources of garnet are concentrated in coarsely crystalline gneiss in the vicinity of North Creek, NY. One of the world's largest known garnet deposits is being quarried in Rangley County, ME. The medium-grained ore from this deposit has an unusually high garnet concentration of 50% to 60%. Significant resources of garnet occur also in Idaho, New Hampshire, and North Carolina. World resources of garnet are large.

11. Substitutes: Garnet is competitive in abrasive applications with natural and manufactured abrasives such as diamond, cubic boron nitride, fused aluminum oxide, silicon carbide, and quartz sand; in filtration media with ilmenite, magnetite, and plastics; and in nonskid surfaces with emery.

GEM STONES 1/

(Data in million dollars)

1. **Domestic Production and Use:** Output of natural gems was primarily from Arizona, Tennessee, Maine, California, and Nevada. Output of synthetic gems was primarily from seven firms, four in California and one each in Massachusetts, Michigan, and New Jersey. It was estimated that 75,000 visitors found 1000 diamonds in the Crater of Diamonds State Park in Arkansas. There was considerable production of freshwater pearls in Tennessee, turquoise in Arizona and Nevada, touramaline in Maine, and tourmaline, kunzite, and garnet in California. Major uses were jewelry, carvings, gem and mineral collections, and industrial.

2. **Salient Statistics--United States:**

	1983	1984	1985	1986	1987 e/
Production: Natural e/	7.4	7.5	7.4	2/9.3	2/13.4
Synthetic	NA	NA	NA	10.3	12.0
Imports for consumption	2,856	3,652	3,680	4,179	4,300
Exports, including reexports	731	681	671	902	700
Consumption, apparent	2,132	2,979	3,016	3,297	3,625
Price	Variable, depending on size, type, and quality				
Stocks, yearend 3/	Not available				
Employment: Mine 4/	200	200	200	300	500
Net import reliance 5/ as a percent of apparent consumption	100	100	100	99	99

3. **Recycling:** Insignificant.

4. **Import Sources (1983-86 by value):** Belgium-Luxembourg, 23%; Israel, 21%; India, 16%; Republic of South Africa, 9%; other, 31%. Diamond imports were about 83% of the total value of gem imports.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Natural precious and semiprecious stones	520.11	Free	Free
Diamond, other, advanced in condition or value	520.31	4.9% ad val.	30% ad val.
Diamond, cut, unset, less than 1/2 carat	520.32, 520.33	Free	10% ad val.
Rubies, sapphires, cut, unset	520.35	Free	10% ad val.
Marcasites, cut, unset	520.37	Free	20% ad val.
Emeralds, cut, unset	520.38	Free	10% ad val.
Other precious/semiprecious stones, jewelry	520.39	2.1% ad val.	30% ad val.
Precious stones, n.s.p.f.	520.51	7.5% ad val.	30% ad val.
Rock crystal, n.s.p.f.	520.54	6% ad val.	50% ad val.
Semiprecious stones	520.61	21% ad val.	50% ad val.
Synthetic gem stones, cut, unset	520.71	3.1% ad val.	10% ad val.
Other synthetic gem stones	520.75	6% ad val.	30% ad val.
Pearls, natural	741.05	Free	10% ad val.
Pearls, cultured	741.06	2.1% ad val.	10% ad val.
Pearls, imitation	741.10	8% ad val.	60% ad val.
Coral, cut but unset	741.15	2.1% ad val.	10% ad val.
Gem stones, imitation, exc. beads	741.35	2.8% ad val.	20% ad val.

6. **Depletion Allowance:** 14% (Domestic), 14% (Foreign).

7. **Government Stockpile:** None.

e/ Estimated. NA Not Available. n.s.p.f. not specifically provided for.

1/ Excludes industrial diamond and garnet, see pages 46-47, and 56-57.

2/ Natural includes production of freshwater pearls, natural and cultured.

3/ Stocks data are not available and are assumed to be zero for apparent consumption and net import reliance calculation.

4/ Estimate includes operators of fee site deposits.

5/ Defined as imports - exports + adjustments for Government and industry stock changes.

6/ Data in thousands of carats of gem diamond.

7/ See page 184 for definitions.

Prepared by Gordon T. Austin, telephone number (202) 634-1206.

8. Events, Trends, and Issues: Imports of rough diamond for cutting, exclusive of industrial applications, were 1.4 million carats, valued at $416 million, a 4% decrease in value compared with that of 1986. The Republic of South Africa was the source of 6% of these imports, compared with 52% in 1986. Imports of cut diamond increased. Imports from India of small gem diamond, 80% of the stones were 10 points or less and valued at an average $203 per carat, amounted to 3.4 million carats or approximately 43% of all U.S. imports of cut of diamond goods.

Except for a few gem diamond finds each year in Arkansas, U.S. production is nil. A small amount of other natural precious gems is produced in the United States and large quantities of better grade natural and synthetic gems are imported. The domestic commercial gem stone mining industry includes jade, opal, and sapphire in the Western States; star garnet from Idaho; turquoise in the Southwestern States; tourmaline in Maine and California, and jade from Alaska. Natural stones commanded higher prices than synthetics for jewelry applications. Heat treatment, and other means, to enhance color and quality of certain types of stones is commonly practiced.

Exploration for diamonds continues in Colorado, Michigan, Minnesota, Wisconsin, and Wyoming. Exploration efforts were started in Alaska during 1987. A diamond mining project in Arkansas, which may impact the Crater of Diamond State Park, is still being evaluated by the State.

9. World Mine Production, Reserves, and Reserve Base: 6/

	Mine Production	
	1986	1987 e/
United States	-	-
Angola	240	190
Australia	13,145	18,150
Botswana	9,610	9,700
Brazil	300	300
Central African Republic	245	245
Ghana	60	60
Guinea	190	200
Guyana	3	3
India	14	14
Indonesia	5	5
Liberia	63	70
Namibia	900	900
Sierra Leone	215	215
South Africa, Republic of	4,635	4,700
Tanzania	210	210
Venezuela	40	40
Zaire	4,661	4,700
China	200	200
U.S.S.R.	4,400	4,400
World Total	39,157	44,302

Reserves and Reserve Base 7/

World reserves and reserve base of gem diamond are substantial. No reserve or reserve base data are availale for other gem stones.

10. World Resources: The world gem diamond reserves are estimated to be about 300 million carats, including near-gem. Most of the reserves are in southern Africa, the U.S.S.R. (Siberia), and Western Australia. Estimation of a reserve base is now more volatile because of the changing economic evaluation of near-gem materials.

11. Substitutes: Plastics, glass, metals, wood, paper, and other materials are substituted for gem stones. Synthetic materials which have the same apperance and chemical and physical properties are substituted for natural gem stones. Simulants are materials of similar appearence, but different chemical and physical properties that are substituted for natural gem stones.

GERMANIUM

(Data in kilograms of germanium content, unless noted)

1. **Domestic Production and Use**: Based on the 1987 yearend published domestic producer price for metal, the value of domestic germanium output was about $24 million. Processed residues from certain domestic ores, industry generated scrap, and imported raw materials were the source materials for germanium production in 1987. The domestic industry consisted of three germanium refineries, one each located in New York, Oklahoma, and Pennsylvania, and two mining operations, one in Tennessee and the other in Utah. The company located in Clarksville, TN, exported germanium bearing residues, generated in the production of zinc metal. A domestic firm recovered germanium and gallium from mined material at its operation near St. George, UT. Companies consuming germanium were located primarily in the Northeast, Texas, and California. The major end uses for germanium were infrared optics, 65%; fiber optic systems, 12%; detectors, 5%; and semiconductors (including transistors, diodes, and rectifiers), 5%. Other applications for germanium included catalysts, phosphors, metallurgy, and chemotherapy.

2. **Salient Statistics--United States**:

	1983	1984	1985	1986	1987 e/
Production, refinery e/	20,000	20,000	22,000	22,000	23,000
Imports for consumption 1/	6,500	6,000	11,000	8,000	12,000
Exports	Not available				
Consumption e/	35,000	35,000	38,000	38,000	40,000
Price, producer, yearend, dollars per kilogram: Zone refined, first reduction quality	1,060	1,060	1,060	1,060	1,060
Dioxide	660	660	660	660	660
Stocks, producer, yearend	Not available				
Employment, plant e/ 2/	80	85	90	90	90
Net import reliance 3/ as a percent of apparent consumption	Not available				

3. **Recycling**: More than 50% of the metal used during the manufacture of most electronic and optical devices is routinely recycled as new scrap. As a result of dispersal in microelectronic devices, very little germanium is returned as old scrap. High purity optical devices may ultimately constitute a large source of recyclable material.

4. **Import Sources (1983-86)**: Belgium-Luxembourg, 38%; China, 18%; United Kingdom, 10%; France, 10%; other, 24%.

5. **Tariff**:

	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Germanium dioxide	423.00	3.7% ad val.	25.0% ad val.
Metal, unwrought, waste and scrap	628.25	3.7% ad val.	25.0% ad val.
Metal, wrought	628.30	5.5% ad val.	45.0% ad val.

6. **Depletion Allowance**: 14% (Domestic), 14% (Foreign).

7. **Government Stockpile**:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Germanium	146,000	-	-	-

e/ Estimated. NA Not available.

1/ Estimated germanium content based on comparison of value per kilogram of imported germanium material with published producer price for germanium metal. Does not include imports of germanium dioxide and other germanium compounds, data for which are not available.

2/ Employment related to primary germanium refining is indirectly related to zinc refining.

3/ Defined as imports - exports + adjustments for Government and industry stock changes.

4/ See page 184 for definitions.

5/ Excludes Zaire.

Prepared by Thomas O. Llewellyn, telephone number (202) 634-1083.

8. **Events, Trends, and Issues:** The largest end use for germanium continued to be in lenses and windows used in the production of infrared sensing and identification systems. Germanium also continued to be used in fiber optic systems.

In September, a Utah plant recovering crude germanium dioxide and gallium metal announced the closure of its mine and refinery plant operations for at least 4 months. During the closure, the company planned to make required equipment changes.

The new goal of 146,000 kilograms of germanium for the National Defense Stockpile (NDS) was established July 24, 1987 after Congress took no action to modify the goal during the 30 days after it was officially proposed by the Federal Emergency Management Agency (FEMA). The General Service Administration (GSA) planned to acquire material to meet the new goal at a rate of 30,000 kilograms per year.

At the end of September, GSA contracted to purchase 23,000 kilograms of zone refined germanium during the third round of bidding toward the previous 30,000-kilogram goal for the NDS. GSA was successful in purchasing 2,000 kilograms and 5,000 kilograms in two previous attempts. In an effort not to disrupt the market, delivery times were stretched out to August 1989. The first purchase was at $666 per kilogram, and the second was at $731 per kilogram. Tightening of supply, probably owing to the GSA purchases, led to prices of $740 to $784 per kilogram for the last contracts. The free market price increased from a range of $700 to $800 per kilogram to about $825 per kilogram when GSA began awarding the contracts in May 1987. All of the contract prices were considerably below the U.S. producer published price, which has been $1,060 per kilogram since 1981. The germanium to be purchased under these contracts for the NDS was expected to come from the United States, France, Israel and Belgium.

The U.S. producer prices for germanium metal and dioxide remained at the levels established in late 1981 ($1,060 and $660 per kilogram, respectively) through October 1986.

Germanium has little or no effect upon the environment because it usually occurs only as a trace element in some ores and carbonaceous materials and only small quantities are employed in commercial usage.

9. **World Refinery Production, Reserves, and Reserve Base:**

	Refinery Production e/		Reserves 4/	Reserve Base 4/
	1986	1987		
United States	22,000	23,000	450,000	500,000
Zaire	NA	NA	200,000	NA
Other Market Economy Countries	41,000	40,000	NA	NA
Centrally Planned Economies	17,000	17,000	NA	NA
World Total	5/80,000	5/80,000	NA	NA

10. **World Resources:** The readily available resources of germanium are in some zinc and lead-zinc-copper sulfide ores and their surficial oxidation products. If germanium were to be recovered from ash and flue dusts resulting from burning certain coals for power generation, potential worldwide germanium resources would become several billion kilograms.

11. **Substitutes:** Less expensive silicon has increasingly been substituted for germanium in certain electronic applications. Certain bimetallic compounds of tellurium, selenium, indium, and gallium may also be used; however, germanium is more reliable in some high-frequency and high-power applications and more economical as a substrate for some light emitting diode applications. In infrared guidance systems, zinc selenide or germanium glass can substitute for germanium metal but at the expense of performance.

GOLD

(Data in million troy ounces of gold content, unless noted)

1. Domestic Production and Use: The domestic mining industry consisted of about 270 lode mines, nearly all in Western States; a dozen or more large placer mines, nearly all in Alaska; and numerous small placer mines located mostly in Alaska and other Western States. About 1% of domestic gold was recovered as a byproduct of processing base metals, chiefly copper. In 1987, 25 mines yielded 90% of the gold produced, and 11 of these accounted for about 65%. The value of 1987 mine production was about $2.2 billion. Commercial-grade refined gold came from about 25 producers; the number of fabricators was about 3,000. Nearly all jewelry manufacturing was centered in the New York, NY, and Providence, RI, areas. Estimated uses in 1987: jewelry and arts, 59%; industrial (mainly electronic), 33%; and dental, 8%.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production: Mine	2.00	2.08	2.43	3.73	4.90
Refinery: Primary	1.97	2.10	2.08	2.43	3.00
Secondary (incl. toll)	3.13	3.30	3.11	3.10	3.70
Imports 1/ 2/ 3/	4.59	7.87	8.23	15.75	3.60
Exports 2/	3.14	4.98	3.97	4.61	2.80
Consumption: Reported	3.10	3.16	3.00	2.98	2.50
Apparent	3.44	3.51	3.34	3.27	2.80
Price, average selling, dollars per ounce	424.00	360.66	317.66	368.24	444.00
Stocks, yearend: Treasury 4/	263.41	262.81	262.67	262.03	262.00
Industry	0.62	0.77	0.62	0.86	0.70
Assigned to futures trading	2.53	2.36	2.11	2.81	2.60
Employment, mine and mill e/	6,500	6,900	6,900	8,300	10,500
Net import reliance 5/ as a percent of apparent consumption	6/	6/	6/	6/	6/

3. Recycling: Of an estimated 3.7 million ounces of gold reclaimed from scrap in 1987, about 2.2 million ounces was from old scrap. The balance was from prompt industrial scrap, partly toll-refined. Old scrap supplied more than one-half of the gold consumed.

4. Import Sources (1983-86): 2/ Canada, 49%; Switzerland, 13%; Uruguay, 9%; other, 29%.

5. Tariff: No duties were imposed on imports of unrefined gold or refined bullion. There were duties on items such as platinum- and silver-plated unwrought or semimanufactured gold, but these items constituted a minor portion of U.S. imports.

6. Depletion Allowance: 15% (Domestic), 14% (Foreign).

7. Government Stockpile: No strategic stockpile. However, the U.S. Department of the Treasury maintains stocks of gold (see section 2 above) and the General Services Administration administers a Government-wide secondary precious metals recovery program.

e/ Estimated. NA Not available.
1/ Imports for consumption.
2/ Excludes gold contained in fabricated items and official monetary gold movement; also excludes estimates of imported gold coin containing, in million ounces; 1.9 (1983), 2.8 (1984), 2.1 (1985), 1.1 (1986), 1.0 (1987).
3/ Excludes net bullion flow (in million ounces) to market from foreign stocks at the New York Federal Reserve Bank: -0.22 (1983), 0.38 (1984), 0.48 (1985), 4.70 (1986), 1.0 (1987 e/).
4/ Includes gold in Exchange Stabilization Fund. Stocks were valued at the official price of $42.22 per troy ounce.
5/ Defined as imports - exports + adjustments for Government and industry stock changes.
6/ The United States is a net importer of gold; however, changes in unreported investor stocks preclude calculation of a meaningful net import reliance.
7/ See page 184 for definitions.
8/ Excludes China and Other Centrally Planned Economies.

Prepared by John M. Lucas, telephone number (202) 634-1070.

8. Events, Trends and Issues: Domestic gold mine production increased about 31% over that of 1986. Over 36 new mines opened in 1987, mainly in Nevada, California, and Montana. Gold continued to be the objective of most metal exploration, domestically and internationally. It is estimated that in 1988 domestic mine production of gold will be about 5.8 million ounces.

Sales by the U.S. Mint of the new legal tender American Eagle gold coin that began on October 20, 1986, reportedly captured 65% of the U.S. bullion coin market during the first full year of sales. On July 1, 1987, the Mint struck the first of up to 1 million gold and 10 million silver coins commemorating the bicentennial of the U.S. Constitution.

The National Union of Mineworkers staged a 3-week strike at gold and coal mines in the Republic of South Africa, winning some increased benefits and allowances but not severely affecting gold production.

The Engelhard Industries/London daily final price of gold ranged from $392.00 to $494.00 during the first 11 months of 1987. Despite the turmoil in the world's stock markets during October, gold continued to sell for over $450 for the remainder of the year, standing at nearly $500 per troy ounce on December 3. The rising prices were generally accompanied by increased gold trading activity on the Nation's gold futures exchanges.

Environmental pollution abatement continued to be of concern to domestic gold producers, especially in Alaska, where there are many small placer mines.

Changes in the reserve and reserve base numbers from numbers published earlier reflect the intensity and success of worldwide gold exploration activity.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 7/	Reserve Base 7/
	1986	1987 e/		
United States	3.73	4.90	117	140
Australia	2.48	3.20	41	45
Canada	3.36	3.80	42	50
South Africa, Republic of	20.51	20.00	760	800
Other Market Economy Countries	9.61	10.80	200	235
China e/	2.10	2.10	NA	NA
U.S.S.R. e/	8.85	8.90	200	250
Other Centrally Planned Economies e/	0.30	0.30	NA	NA
World Total	50.94	54.00	8/ 1,360	8/ 1,520

The world's estimated above-ground gold stocks, excluding gold in industrial usage, total about 2.7 billion ounces, of which 1.14 billion ounces are official stocks of the market economy countries, 0.09 billion ounces are official stocks of centrally planned economy countries, and 1.44 billion ounces are privately held as coin, bullion, or jewelry. Gold lost, unrecoverable, unaccounted for and dissipated in industrial uses accounts for the remainder of total estimated gold mined in historical times, through 1987; about 3.3 billion ounces.

10. World Resources: Total world resources of gold are estimated at 2.4 billion ounces, of which 15% to 20% are byproduct resources. The Republic of South Africa has about one-half of world resources, and the U.S.S.R., Brazil, and the United States about 12% each. Some of the 0.28-billion-ounce U.S. resource would be recovered as byproduct gold.

11. Substitutes: Base metals clad with gold alloys are being used increasingly in electrical/electronic and jewelry products to economize on gold; many of these products are being redesigned to maintain high utility standards with lower gold content. Generally, palladium, platinum, and silver may substitute for gold.

GRAPHITE (NATURAL)

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use**: Natural graphite was not produced domestically in 1987. Apparent consumption of natural graphite, 36,000 tons valued at $13.0 million, was by several hundred manufacturing firms located primarily in the northeastern and Great Lakes regions. The main uses of natural graphite were estimated to be: refractories, 25%; lubricants, 15%; dressings and molds in foundry operations, 14%; brake linings, 13%; pencils, 6%; steelmaking, 5% and other, 22%.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, mine	W	W	-	-	-
Imports for consumption	44	58	53	43	47
Exports	9	7	8	8	11
Consumption, apparent	W	W	44	35	36
Price, imports (average dollars per ton at foreign ports):					
Flake	550	509	536	648	730
Lump and chip (Sri Lankan)	1,158	1,065	790	932	854
Amorphous (Mexican)	56	40	50	49	53
Stocks, yearend		Not available			
Employment, mine, mill, and processing plant	W	W	-	-	-
Net import reliance 1/ as a percent of apparent consumption	W	W	100	100	100

3. **Recycling**: None.

4. **Import Sources (1983-86)**: Mexico, 45%; China, 26%; Brazil, 9%; Madagascar, 6%; other, 14%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crystalline flake (not including flake dust):			
Valued not over 5.5¢/lb	517.21	3% ad val.	1.65¢/lb
Valued over 5.5¢/lb	517.24	0.3¢/lb	1.65¢/lb
Lump and chip	517.27	Free	30% ad val.
Other	517.31	Free	10% ad val.

6. **Depletion Allowance**: 22% (Domestic lump and amorphous), 14% (Domestic flake), 14% (Foreign).

7. **Government Stockpile**: In addition to data shown below, the stockpile contained 932 tons of nonstockpile-grade material.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Sri Lanka, amorphous lump	6	5	-	-
Madagascar, crystalline flake	20	18	-	-
Other than Sri Lanka and Madagascar crystalline	3	2	-	-

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.

1/ Defined as imports - exports + adjustments for Government and industry stock changes. Data on changes in stocks were not available and were assumed to be zero in the calculations.

2/ See page 184 for definitions.

Prepared by Harold A. Taylor, Jr., telephone number (202) 634-1180.

8. Events, Trends, and Issues: Availability of graphite was adequate during 1987. Demand was met largely by imports of flake from Brazil, Madagascar, and China, lump and chip from Sri Lanka, and amorphous graphite from Mexico and China. Imports of all kinds of graphite were up 9% from those of 1986. Exports were up substantially, but remained relatively small.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 2/	Reserve Base 2/
	1986	1987 e/		
United States	-	-	Very Small	Small
Austria	39	40	Large	Large
India	33	35	Moderate	Moderate
Korea, Republic of	74	70	Large	Large
Madagascar	16	15	Large	Large
Mexico	41	40	Large	Large
Sri Lanka	8	10	Moderate to Large	Moderate to Large
Other Market Economy Countries	61	60	Moderate	Moderate
Centrally Planned Economies	401	400	Large	Large
World Total	673	670	e/32,000	e/165,000

10. World Resources: Domestic resources are relatively small, while the rest of the world's resources exceed 1.5 billion tons of recoverable graphite. Deposits in Alabama, Alaska, Montana, New York, Pennsylvania, and Texas were not economically viable.

11. Substitutes: Substitute materials are more costly and/or do not perform as well as natural graphite for most applications. Manufactured graphite powder, scrap from discarded machined shapes, and calcined petroleum coke compete for use in iron and steel production. Finely ground coke with olivine is a potential competitor in foundry facing operations. Molybdenum disulfide competes as a dry lubricant but is more sensitive to oxidative conditions.

GYPSUM

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use:** In 1987, output of crude gypsum was 15.8 million tons valued at $102 million, about the same tonnage and value as that of 1986. Leading States were Texas, Michigan, Iowa, Oklahoma, California, and Nevada, which together accounted for 65% of the total. Thirty-five companies mined crude gypsum at 63 mines in 20 States, and 14 companies calcined gypsum at 72 plants in 29 States. Of the total supply of crude gypsum, 26.1 million tons, including 700,000 tons of byproduct gypsum, 20.7 million tons was calcined for gypsum products, and 5.4 million tons was used mainly as a cement retarder or as agricultural land plaster. The calcined gypsum was sold as prefabricated products or as industrial or building plaster. Sales of gypsum for use in cement were 4.1 million tons; for agriculture, 1.2 million tons; and for industrial and building plaster, 0.58 million tons.

   Available capacity of operating gypsumboard plants in the United States at yearend 1987 was 23.5 billion square feet per year. Sales of gypsumboard products were 20.7 billion square feet, which represented a capacity utilization of 88%.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Crude	12,884	14,319	14,726	15,789	15,800
Byproduct	760	780	779	653	700
Calcined	13,902	15,450	15,982	17,061	16,800
Prefabricated products (million square feet)	16,763	18,314	19,523	21,301	20,700
Imports, crude, including anhydrite	8,031	8,904	9,922	9,559	9,600
Exports, crude, not ground or calcined	6	6	4	15	4
Consumption, crude, apparent 1/	22,710	24,221	25,111	25,594	26,100
Price: Average crude, f.o.b. mine, dollars per ton	7.87	7.94	7.76	6.46	6.50
Average calcined, f.o.b. plant, dollars per ton	19.43	20.75	23.53	18.19	19.00
Stocks, producer, crude, yearend	2,950	2,726	3,038	3,430	3,426
Employment, mine and calcining plant	6,500	6,600	6,700	6,700	6,700
Net import reliance 2/ as a percent of apparent consumption	40	38	38	36	37

3. **Recycling:** Byproduct gypsum generated in flue gas desulfurization, phosphate rock acidulation, and other chemical processes is not reclaimed, except for a small amount sold for agricultural and wallboard purposes.

4. **Import Sources (1983-86):** Canada, 67%; Mexico, 21%; Spain, 12%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude, not ground or calcined	512.21	Free	Free
Ground, wholly or partly calcined 3/	512.24	42¢	$1.40
Plaster of paris articles, n.s.p.f.	512.44	Free	60% ad val.
Alabaster articles, n.s.p.f.	513.94	Free	50% ad val.
Gypsum or plaster building board	245.70	2.4% ad val.	30% ad val.

6. **Depletion Allowance:** 14% (Domestic), 14% (Foreign).

7. **Government Stockpile:** None.

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e/ Estimated. n.s.p.f. not specifically provided for.
1/ Defined as crude + byproduct + net import reliance.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ Per long ton.
4/ See page 184 for definitions.

Prepared by Lawrence L. Davis, telephone number (202) 634-1206.

8. Events, Trends, and Issues: The gypsum industry in 1937 followed the continued high activity of the construction and housing industries. Housing starts were over 1.6 million compared with 1.8 million in 1986. Production of domestic crude gypsum, imports of crude gypsum, and sales of prefabricated products each increased slightly.

In 1987, the gypsum wallboard industry continued the high rate of shipments established in 1986. Total wallboard shipments for 1987 were 20.7 billion square feet, a slight increase over those of 1986 and a new annual record. Expansions and improvements in existing line operations brought yearend gypsum board capacity to 23.5 billion square feet per year. Capacity was sufficient to meet demand without any serious shortages developing. The average price of wallboard in 20 principal cities decreased slightly. Imports of wallboard, principally from Canada, were 770 million square feet, 8% less than those of 1986. Wallboard exports to 33 different countries were 61 million square feet.

As long as the cost of land for solid waste disposal continues to be economical and solid waste pollution remains noncritical, only a small amount of the potentially useful byproduct gypsum scrubbed from powerplant stack gases and produced by chemical plants will be used. For the first time in the United States, a gypsum wallboard plant, based solely on a synthetic gypsum feed, began production in northeast Texas.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States	15,789	15,800	800,000	Large
Australia	1,760	1,800		
Canada	9,420	9,500	500,000	Large
France	6,000	6,000		
Germany, Federal Republic of	2,090	2,100		
Iran	5,500	5,500		
Italy	1,430	1,500	Reserves and Reserve Base are large in major producing countries but data are not available.	
Japan	7,000	7,000		
Mexico	4,960	5,000		
Spain	6,060	6,100		
United Kingdom	3,530	3,500		
Other Market Economy Countries	14,542	14,600		
China	7,200	7,500		
Poland	1,980	2,000		
Romania	1,700	1,700		
U.S.S.R.	5,500	5,500		
Other Centrally Planned Economies	2,095	2,100		
World Total	96,556	97,200	2,600,000	Large

10. World Resources: Domestic resources are adequate but are unevenly distributed. There are no gypsum deposits on the eastern seaboard of the United States, and large imports from Canada augment the domestic supply of crude ore in these industrial areas. Large deposits occur in the Great Lake region, mid-continent region, California, and other States. Foreign resources are adequate but are not evenly distributed.

11. Substitutes: Other construction materials may be substituted for gypsum, especially lime, lumber, cement, steel, or masonry. There is no practical substitute for gypsum in portland cement. Byproduct gypsum is presently substituting for crude gypsum in special agricultural applications, and is beginning to be utilized in place of crude gypsum for cement set-retarding and manufacturing wallboard.

HAFNIUM 1/

(Data in short tons of hafnium content, unless noted)

1. Domestic Production and Use: Hafnium is recovered as a byproduct in the production of hafnium-free, nuclear-grade, zirconium-base alloys. Two companies, one with a plant in Oregon and another with a plant in Utah, produced primary hafnium sponge and hafnium crystal bar. Uses were in nuclear reactors, ceramics, refractory applications, alloys, and as carbide in cutting tool alloys.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production: Sponge	W	W	W	W	W
Crystal bar e/	50	50	50	50	50
Imports for consumption	Negligible				
Exports	None				
Consumption, apparent: Sponge	W	W	W	W	W
Crystal bar e/	50	55	55	55	55
Price, sponge, dollars per pound, domestic 2/	70-125	80-130	80-130	80-130	90-140
Stocks, yearend, sponge and crystal bar e/	35	30	30	30	30
Employment, metal plant	3/	3/	3/	3/	3/
Net import reliance 4/ as a percent of apparent consumption	W	W	W	W	W

3. Recycling: Insignificant.

4. Import Sources (1983-86): France, 100%.

5. Tariff:

	Number	Most Favored Nation (MFN) 1/1/87	(Non-MFN) 1/1/87
Unwrought hafnium, waste and scrap	628.35	Free	25.0% ad val.
Wrought hafnium	628.40	9.0% ad val.	45.0% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ See also Zirconium.
2/ Price varies with quantities purchased.
3/ Small portion of primary zirconium metal plant employment.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ See page 184 for definitions.

Prepared by W. Timothy Adams, telephone number (202) 634-1058.

8. Events, Trends, and Issues: The use of hafnium as an alloying agent in high-temperature refractory alloys, and in hafnium-columbium carbide for cutting tools, continued to grow in 1987. It is estimated that in 1988 domestic production and consumption of hafnium crystal bar will each be about 50 tons. Hafnium is available at reasonable cost as long as there is a continuing demand for reactor-grade zirconium.

9. World Mine Production, Reserves, and Reserve Base: World primary hafnium production statistics are not available. Hafnium occurs with zirconium in the mineral zircon. The U.S. reserves of hafnium associated with zircon amounts to about 80,000 tons. The U.S. reserve base 5/ of hafnium associated with zircon amounts to about 160,000 tons.

10. World Resources: Resources of hafnium in the United States are estimated to be 140,000 tons, available in the 14-million-ton domestic resources of zircon. World resources of hafnium are associated with those of zircon, and exceed 500,000 tons.

11. Substitutes: There are no substitutes for hafnium in its major applications in nuclear reactors and in refractory metal alloys, but zirconium oxide and metal can be substituted in selected refractories and ceramics.

HELIUM

(Data in million cubic feet of contained helium gas
measured at 14.7 psia and 70° F, unless noted)

1. Domestic Production and Use: During 1987, the estimated value of Grade-A (99.995% or better) helium extracted at the Bureau of Mines Exell, TX, Helium Plant was $10 million, and the estimated value of Grade-A helium extracted by private industry was $68 million. The total sales value for domestic consumption and exports was $78 million. Eight private industry plants and one Bureau of Mines facility extracted helium from natural gas; four of the privately owned plants were in Kansas, one in New Mexico, two in Texas, and one in Wyoming. The Grade-A helium produced was consumed principally in Western and Gulf Coast States. The estimated 1987 domestic consumption of 1,640 million cubic feet was used primarily for cryogenic applications, 25%; for welding cover gas, 25%; for pressurizing and purging, 23%; and for controlled atmospheres, 12%.

2.

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Helium extracted from natural gas 1/	575	1,174	997	995	1,800
Grade-A helium sales	1,363	1,637	1,883	1,941	2,100
Imports for consumption	None				
Exports 2/	368	392	439	432	460
Consumption, apparent 2/	995	1,245	1,444	1,509	1,640
Employment, plant 2/	550	550	550	580	580
Net import reliance 3/ as a percent of apparent consumption	Net exporter				

Price: The Bureau's price of Grade-A gaseous helium, f.o.b. Bureau plants, was $37.50 per thousand cubic feet during 1987. Private producers of helium maintained their selling price of Grade-A helium gas at about $37.00 per thousand cubic feet, and the price of liquid helium at about $55.00 per thousand cubic feet, including surcharges.

3. Recycling: In the United States, helium used in large-volume applications is seldom recycled. Some low-volume or liquid boiloff recovery systems are used. In Western Europe and Japan, helium recycling is practiced when economically feasible.

4. Import Sources (1983-86): None.

5.

Tariff:	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Helium	415.50	3.7% ad val.	25.0% ad val.

6. Depletion Allowance: Allowances are applicable to natural gas from which helium is extracted, but none is granted directly to helium.

7. Government Stockpile: The Bureau of Mines stockpile is a separate operation run pursuant to Public Law 86-777. The Bureau accepted 622 million cubic feet of private helium for storage and redelivered 714 million cubic feet for a net reduction in storage of 92 million cubic feet. On September 30, 1987, 36.0 billion cubic feet of helium was in storage, of which 1.7 billion cubic feet was owned by private firms.

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e/ Estimated. NA Not available.
1/ Helium content of both Grade-A and crude helium (consisting of approximately 70% helium and 30% nitrogen).
2/ Grade-A helium.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions.
5/ All domestic measured and indicated helium resources in the United States.
6/ Excludes Other Market Economy Countries.

Prepared by William D. Leachman. For further information call Armond A. Sonnek, Assistant Director--Helium Operations, (202) 634-4734.

8. Events, Trends, and Issues: The new privately owned plant in Wyoming was brought onstream in the last quarter of 1986. The plant has operated reliably since that time, producing helium at expected rates. The new Kansas plant, originally scheduled for operation in 1985, remains idle pending the outcome of litigation.

It is estimated that in 1988 domestic production of helium will be 2.2 billion cubic feet, and U.S. apparent consumption will be 1.7 billion cubic feet.

9. World Production, Reserves, and Reserve Base:

	Production		Reserves 4/5/	Reserve Base 4/5/
	1986	1987 e/		
United States (sales)	1,941	2,100	229,000	521,000
Other Market Economy Countries	NA	NA	NA	NA
Centrally Planned Economies e/	150	150	NA	NA
World Total	6/2,091	6/2,250	NA	

10. World Resources: The identified helium resources of the United States are estimated to be 521 billion cubic feet. This includes 36 billion cubic feet of helium stored in the Cliffside field, 223 billion cubic feet of helium in helium-rich natural gas (0.30% helium or more), and 262 billion cubic feet in helium-lean natural gas (less than 0.30% helium). It is postulated that by the end of the century, most of the helium-rich natural gasfields currently supplying helium will be exhausted, except for the Riley Ridge field. These currently depleting gasfields contain an estimated 170 billion cubic feet of helium. The remaining 53 billion cubic feet of helium-rich gas resources is nondepleting. Riley Ridge contains 99 billion cubic feet of helium of which 85 billion cubic feet is now included in the depleting classification, as this gas is now being produced. Future supplies will come from known helium-rich natural gas with little fuel value. The identified helium-lean resources of 262 billion cubic feet include 38 billion cubic feet of measured and 224 billion cubic feet of indicated helium resources.

Helium resources in the world exclusive of those in the United States and the centrally planned economies were estimated to be 203 billion cubic feet. The locations and volumes of the principal deposits in billion cubic feet are Algeria, 74; Canada, 70; and the Netherlands, 26. As of December 31, 1987, the Bureau of Mines had analyzed 18,504 gas samples from 37 countries and the United States in a program to identify world helium resources.

11. Substitutes: No substance can be substituted for helium if temperatures below -429° F are required. Argon can be substituted for helium in welding, and hydrogen can be substituted for helium in some lighter-than-air applications where the flammability of hydrogen is not objectionable. Hydrogen is also being investigated as a substitute for helium in deep sea diving applications below 1,000 feet.

ILMENITE 1/

(Data in thousand short tons of ilmenite, unless noted)

1. Domestic Production and Use: Two firms produced ilmenite concentrate from three heavy mineral sand operations in Florida. Based on average prices the value of reported U.S. ilmenite and titanium slag consumption in 1987 totaled $150 million. Major coproducts of ilmenite from sand deposits are zircon and rutile. Ilmenite and titanium slag were consumed by 10 companies. Four titanium pigment producers used 99% of the ilmenite and titanium slag consumed. The rest was used in welding-rod coatings and for manufacturing metal, alloys, carbide, and chemicals.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production	W	W	W	W	W
Imports for consumption 2/	398	619	799	827	850
Exports	1	4	-	2	-
Consumption: Reported 2/	897	984	1,008	1,083	1,150
Apparent 2/	W	W	W	W	W
Price, dollars per metric ton:					
Ilmenite:					
54% TiO_2, f.o.b. Atlantic ports	70	70	NA	NA	NA
Domestic, f.o.b. U.S. east coast	44	44	53	53	53
Slag e/:					
74%-80% TiO_2, f.o.b. Sorel, Quebec 3/	162	185	196	213	225
85% TiO_2, f.o.b. Richards Bay, Republic of South Africa	180	200	212	228	250
Stocks, mine, distributor and consumer, yearend 2/	477	268	343	377	340
Employment, mine and mill 4/	370	382	429	385	373
Net import reliance 5/ as a percent of apparent consumption	W	W	W	W	W

3. Recycling: None.

4. Import Sources (1983-86): 2/ Australia, 61%; Canada, 26%; Republic of South Africa, 13%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Titanium ore (including ilmenite and ilmenite sand)	601.5120	Free	Free
Titanium slag	603.6200	Free	Free

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ See also Rutile and Titanium.
2/ Includes titanium slag from Canada and the Republic of South Africa, and leucoxene from Australia.
3/ Contained 74% TiO_2 in January to October 1983, then 80% TiO_2.
4/ Includes operating employees shown under Rutile, subject to the same footnoted comments.
5/ Defined as imports - exports + adjustments for Government and industry stock changes.
6/ See page 184 for definitions.
7/ Excludes U.S. production.

Prepared by Langtry E. Lynd, telephone number (202) 634-1073.

8. **Events, Trends, and Issues:** In 1987 domestic mine production of ilmenite was about the same as in 1986. Imports increased slightly.

It is estimated that in 1988 U.S. consumption of ilmenite, including slag, will be about 1.2 million tons.

Environmental problems related to ilmenite include: (1) Land-use conflicts where heavy mineral sand deposits exist, principally along the Atlantic coast, and (2) the potential for water pollution from pigment-producing processes that use ilmenite. Solutions to the latter problem include the development of economic and environmentally acceptable processes for making synthetic rutile or titanium tetrachloride from lower grade ilmenites, and the development of methods to neutralize and control the effluents now produced. Synthetic rutile was produced at one domestic plant, at Mobile, AL, using Australian ilmenite as feed material. The two U.S. producers using the sulfate process treated their spent acid effluent with calcium carbonate and lime, producing a gypsum byproduct, part of which was sold to wallboard and cement manufacturers and for agricultural use. One company upgrades part of its waste ferric chloride effluent for use in water treatment, and uses deep-well disposal of ferric chloride at most of its pigment plants.

In Canada, plans were announced for a 20% expansion of 80% titanium dioxide (TiO_2) slag production, to slightly more than one million tons per year by mid-1988. At Richards Bay, Republic of South Africa, production of 85% TiO_2 slag was close to full capacity following installation of a third smelting furnace in 1986. The new ilmenite smelting plant at Tyssedahl, Norway, designed to produce 220,000 tons per year of 75% TiO_2 slag, was in a startup phase during most of 1987. Financial problems caused the new plant to close in late November. Larger than anticipated capital expenditures had been made in attempts to overcome equipment problems, and a Government investment of at least $23 million was being sought.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production		Reserves[6]	Reserve Base[6]
	1986	1987[e]		
United States	W	W	14,000	57,000
Australia	1,441	1,600	45,000	72,000
Brazil	50	50	3,000	3,000
Canada (slag production)	937	990	60,000	160,000
Egypt	-	-	-	3,000
Finland	-	-	3,000	3,000
India	154	165	60,000	60,000
Italy	-	-	-	19,000
Madagascar	-	-	-	27,000
Malaysia	438	440	-	2,000
Norway (both ilmenite and slag production)	884	900	70,000	195,000
South Africa, Republic of (slag production)	480	650	80,000	100,000
Sri Lanka	110	110	8,000	8,000
China	160	160	65,000	90,000
U.S.S.R.	490	490	13,000	27,000
World Total	[7]5,144	[7]5,555	421,000	826,000

10. **World Resources:** Ilmenite supplies about 90% of the world's demand for titaniferous material. World ilmenite resources total about 1 billion tons of titanium dioxide. Major resources occur in Australia, Canada, India, Norway, the Republic of South Africa, the United States, the U.S.S.R., and China.

11. **Substitutes:** Rutile and synthetic rutile were also extensively used to produce titanium dioxide pigment.

INDIUM

(Data in thousand troy ounces of metal, unless noted)

1. **Domestic Production and Use:** Domestic indium production was derived from residues generated in the refining of zinc and other base metal concentrates. Two companies in New York and Rhode Island refined indium from these materials during 1987. Several firms located in Eastern States produced high purity shapes, alloys and compounds from indium ingots. Estimated uses for the metal in 1987 were: electrical and electronic components, 40%; solders, alloys, and coatings, 45%; and research and other, 15%. The estimated value of consumption in 1987, based on the average price, was $5.8 million.

2. **Salient Statistics--United States:**

	1983	1984	1985	1986	1987 e/
Production, refinery		Not available			
General imports, metal	1,073	1,022	980	1,380	1,400
Exports		Not available			
Consumption e/	500	600	600	700	800
Price, average annual, dollars per troy ounce	3.19	3.00	2.63	2.61	7.30
Stocks, producer, yearend		Not available			
Employment		Not available			
Net import reliance 1/ as a percent of apparent consumption		Not available			

3. **Recycling:** Recycling of old scrap is insignificant. Small quantities of new scrap generated during manufacturing processes are recycled.

4. **Import Sources (1983-86):** Italy, 22%; Belgium-Luxembourg, 20%; France, 17; United Kingdom, 15%; other, 26%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Unwrought and waste and scrap	628.45	Free	25.0% ad val.
Wrought	628.50	3.6% ad val.	45.0% ad val.
Compounds	423.96	Free	25.0% ad val.

6. **Depletion Allowance:** 14% (Domestic), 14% (Foreign).

7. **Government Stockpile:** None; but indium was selected for further study as a possible candidate for acquisition for the National Defense Stockpile (NDS) by an ASM International panel consisting of representatives from industry and government. The panel included representatives from the U.S. Department of Commerce, the U.S. Department of Defense, the Bureau of Mines, the Federal Emergency Management Agency, and the General Services Administration.

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e/ Estimated. NA Not available.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ Estimate based on indium content of zinc ores. See page 184 for definitions.
3/ Excludes production from Other Market Economy Countries and the United States.

Prepared by Robert D. Brown, Jr., telephone number (202) 634-1063.

8. **Events, Trends, and Issues:** In recent years, domestic indium production was estimated to have fluctuated within a relatively narrow range. In 1987, domestic production increased slightly while demand increased substantially.

In 1987, the domestic producer price of indium increased from $2.87 to $9.95 per troy ounce from January to July and remained at that level the rest of the year. Industry sources attribute the strong price rise to increases in Asian demand for electronic applications. No toxic effects of indium have been reported and no special treatment has been required to remove it from waste products at base metal smelters and refineries.

Established uses for indium included plating on electronic components, low melting alloys, solders, coatings on electrical contacts, dental alloys, nuclear reactor control rods, infrared detectors, and aircraft windshield coatings. A growing use was as a transparent, electrically conductive coating on glass, such as used for liquid-crystal displays on wristwatches, calculators, and computer touch screens. Research continued on the use of indium in semiconductor devices and of indium and indium-tin oxide coatings for residential, commercial, and automobile windows and solar cells.

9. **World Production, Reserves, and Reserve Base:**

	Refinery Production e/		Reserves 2/	Reserve Base 2/
	1986	1987		
United States	NA	NA	7,000	17,000
Canada	180	70	8,000	18,000
Japan	540	630	2,000	4,000
Peru	100	200	3,000	4,000
Other Market Economy Countries	NA	NA	24,000	37,000
U.S.S.R.	200	200	6,000	8,000
Other Centrally Planned Economies	300	300	4,000	8,000
World Total	3/1,320	3/1,400	54,000	96,000

10. **World Resources:** Identified resources of indium occur primarily in zinc sulfide ores in many parts of the world. However, the indium content is not the same in all zinc ores.

11. **Substitutes:** Alternate materials are available for most uses of indium. In transistors, silicon has generally replaced germanium-indium. For some alloys, if cost is not an important factor, gallium can be used as a substitute. Boron carbide and hafnium can replace indium in nuclear reactor control rods.

IODINE

(Data in thousand pounds, unless noted)

1. Domestic Production and Use: The large operation at Woodward, OK, continued production of iodine from subterranean brines. A second company operated two miniplants in Kingfisher County, OK, using waste brine associated with oil production. Twenty-four plants reported consumption of iodine in 1986. Prices and consumption of crude iodine rose during 1987.

   Establishing an accurate end-use pattern for iodine was inhibited because intermediate iodine compounds were marketed before reaching their ultimate end uses. The downstream uses of iodine were animal feed supplements, catalysts, inks and colorants, pharmaceuticals, photographic equipment, sanitary and industrial disinfectants, stabilizers, and other uses.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 [e]
Production	W	W	W	W	W
Imports for consumption, crude content	6,200	5,100	5,400	5,800	6,000
Exports		Not Available			
Shipments from Govt. stockpile excesses	50	109	-	190	610
Consumption: Apparent	8,100	W	W	W	W
Reported	5,701	5,527	5,172	5,136	5,000
Price, average CIF value, dollars per pound, crude	5.57	4.90	5.39	5.68	6.68
Stocks, producer, yearend	W	W	W	W	W
Employment, processing plant	[1]430	50	50	30	30
Net import reliance [2] as a percent of apparent consumption	W	W	W	W	W

3. Recycling: Iodine was recycled, but no data are available.

4. Import Sources (1983-86): Japan, 71%; Chile, 27%; other, 2%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Iodine, crude	415.25	Free	Free
Iodine, resublimed	415.27	6.0¢/lb	10.0¢/lb
Potassium iodide	420.20	2.8% ad val.	7.5% ad val.

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: In addition to the quantity shown below, the stockpile contains 1,342 pounds of nonstockpile-grade material available for disposal.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Stockpile grade	5,800	6,571	-	610

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[e] Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1] Includes bromine.
[2] Defined as imports - exports + adjustments for Government and industry stock changes.
[3] See page 184 for definitions.
[4] Excludes U.S. production.
[5] Excludes other market economy countries.
[6] Excludes other market economy countries and the U.S.S.R.

Prepared by Phyllis A. Lyday, telephone number (202) 634-1177.

8. Events, Trends, and Issues: A Japanese-owned company announced the purchase of brine leases and the building of a new plant to be completed by yearend 1987 in Vici, OK. The nameplate plant capacity was announced as being 1 million pounds per year, but actual production will depend upon the quantity and quality of the brines. The commencement of production from this brine field, the last known field that contains high iodine concentration in commercially available supply, will help to alleviate the import dependence of this stockpile material. Iodine was produced in California prior to 1960, but the quality of the brine was low and production ceased when Japan was able to provide a source.

The General Services Administration reached the authorized disposal levels and discontinued in April the payment of iodine excess from the National Defense Stockpile for the processing of ferroalloys.

The major world producer, Japan, produced iodine from brines associated with gas production. Japan continued to drill new wells to recover gas and the brines used to produce iodine. The second largest producer of iodine, Chile, produced iodine as a coproduct of sodium nitrate.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States	W	W	550,000	550,000
Chile	6,600	7,000	900,000	1,200,000
Indonesia	33	30	100,000	100,000
Japan	16,300	16,300	4,000,000	7,000,000
Other Market Economy Countries	-	-	NA	NA
China	1,000	1,000	400,000	400,000
U.S.S.R.	4,400	4,400	400,000	400,000
Other Centrally Planned Economies	-	-	-	NA
World Total (may be rounded)	4/28,300	4/28,700	5/6,350,000	6/9,650,000

10. World Resources: In addition to the fields listed in the reserve base, seawater contains 0.05 parts per million iodine, or approximately 76 billion pounds. Seaweeds of the Laminaria family are able to extract and accumulate up to 0.45% iodine on a dry basis. While not as economical as the production of iodine as a byproduct of gas, oil, and nitrate, the seaweed industry represented a major source of iodine prior to 1959 and a large resource.

11. Substitutes: Bromine and chlorine could be substituted for most of the biocide, ink, and colorant uses of iodine, although they are usually considered less desirable. Antibiotics and mercurochrome also substitute for iodine as biocides. Salt crystals and finely divided carbon may be used for cloud seeding. There are no substitutes in some catalytic, nutritional, pharmaceutical, animal feed, and photographic uses.

IRON ORE 1/

(Data in million long tons of ore, 2/ unless noted)

1. Domestic Production and Use: Value of usable iron ore shipped from domestic mines in 1987 was estimated at $1.6 billion. Iron ore was produced by 18 companies operating 18 mines, 14 concentration plants, and 9 pelletizing plants. The mines included 17 open pits and 1 underground operation. Virtually all ore was concentrated before shipment, and about 96% was pelletized. Average iron content of usable ore was about 64%. Ten mines operaced by eight companies accounted for 99% of the output. Domestic steel companies directly controlled about 81% of production. Minnesota produced about 71% of the output, Michigan 25%, and the rest was produced in six other States. Consumption of iron ore and agglomerates was distributed approximately as follows: blast furnaces, 97.6%; direct reduction plant, 0.3%; steel furnaces, 0.2%; and manufacture of cement, heavy media materials and other products, 1.9%. Approximate consumption by region was: Illinois-Indiana-Michigan, 50%; Ohio-Pennsylvania, 31%; Maryland-West Virginia, 13%; the remainder mostly in three other States.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, usable	37.6	51.3	48.8	38.8	43.1
Shipments	44.6	50.9	49.4	41.3	44.8
Imports for consumption	13.2	17.2	15.8	16.7	15.3
Exports	3.8	5.0	5.0	4.5	4.1
Consumption: Reported (ore and agglomerates)	70.6	72.5	70.6	61.1	64.9
Apparent	60.0	64.1	62.3	58.4	59.8
Price (Nov.), Lake Superior ores, delivered rail of vessel at lower lake ports:					
Natural ores, basis 51.5% Fe, dollars per long ton	30.03-32.78	30.03-32.78	30.03-32.78	30.03-32.78	30.03-32.78
Pellets, cents per long ton unit of Fe	80.5-86.9	80.5-86.9	58.0-86.9	58.0-86.9	58.0-86.9
Stocks, mine, dock, and consuming plant, yearend, excl. byproduct ore	32.8	32.2	29.6	22.4	17.0
Employment, mine, concentrating and pelletizing plant, quarterly average	7,600	8,200	8,200	6,000	5,200
Net import reliance 3/ as a percent of apparent consumption (iron in ore)	37	19	21	33	28

3. Recycling: Insignificant.

4. Import Sources (1983-86): Canada, 59%; Brazil, 16%; Venezuela, 12%; Liberia, 11%; other, 2%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Iron ore	601.24	Free	Free

6. Depletion Allowance: 12.00% (Domestic) and 11.2% (Foreign).

7. Government Stockpile: None.

8. Events, Trends, and Issues: The world supply of iron ore continues to exceed demand. The completion of new mines in Brazil, India, and Venezuela can only exacerbate the deteriorating situation facing many marginal producers. Loss of market share and the fall of prices over the last 4 years kept several established producers from upgrading their facilities. World iron ore production and consumption both increased slightly between 1986 and 1987. Most prices for lump ore and fines declined 3% to 10% from 1986 levels. Pellet prices, in contrast, rose 2% to 5%, encouraging a few foreign producers to restart idled pelletizing lines. The iron ore industry of the United States and Canada has been undergoing a major restructuring since 1985 aimed at lowering pellet costs and improving its financial health.

e/ Estimated.
1/ See also Iron and Steel, and Iron and Steel Scrap.
2/ Usable ore, including byproduct ore.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions of reserves and reserve base. For several countries, reserve base was tentatively assumed to equal reserves because available data were inadequate to define or estimate certain marginal economic or sub-economic components of the reserve base.
5/ MEC = Market Economy Countries; CPE = Centrally Planned Economies.

Prepared by Peter H. Kuck, telephone number (202) 634-1023.

In the United States, production of ore and agglomerates was only 6% more than that of 1986, the second worst year for the industry since 1939. Demand for domestic pellets has remained weak because of the dramatic contraction of the U.S. steel industry in the last 5 years and the relatively high costs of production and transport. High rail rates continued to hamper the sale of domestic pellets to blast furnaces on the Atlantic and Gulf coasts. One of the country's 10 pelletizing plants remained closed as a result of bankruptcy proceedings, while another was idled for the first 4 months of 1987 by a labor dispute. Major efforts to reduce costs were continued, but attempts to improve productivity were hindered by a shortage of capital to replace aging equipment. Taxes and electric power contracts remained significant issues in Minnesota. The sharp decline of the stock market in October threatened to slow the recovery of the iron ore and steel industries, which were seriously hurt by the 1982-83 recession. The volatility of the financial situation in the fourth quarter of 1987 made it difficult for taconite mining ventures to refinance long-term debts, and discouraged companies throughout the entire heavy industry sector from making capital expenditures.

Environmental concerns in the iron ore industry continued to include reclamation and disposal of process water and solid waste, reduction of dust and noise, control of groundshock from blasting, and updating epidemiological studies on the relation of taconite dust to health. Technological research concerned the use of dolomite for production of magnesic fluxed pellets, plasma-arc smelting of iron ore concentrates, direct reduction of pellets using solid fuels, substitution of organic binders for bentonite, and reduction of fuel costs by the use of coke breeze or coal-water slurries.

It is estimated that in 1988, domestic production of iron ore will be 39 million tons and U.S. apparent consumption will be 58 million tons.

9. World Mine Production, Reserves, and Reserve Base: 4/

	Mine Production		Crude ore (million long tons)		Iron content (million short tons)	
	1986	1987 e/	Reserves	Reserve base	Reserves	Reserve base
United States	38.8	43.1	15,800	24,800	3,700	5,900
Australia	88.6	88.0	15,000	33,000	10,100	20,200
Brazil	129.9	134.0	15,600	17,300	10,800	11,300
Canada	35.5	33.0	11,700	25,100	4,500	9,800
France	12.2	12.0	2,200	2,200	900	900
India	47.0	54.0	7,100	11,900	4,800	7,500
Liberia	15.1	15.0	900	1,600	500	800
South Africa, Republic of	24.1	24.0	4,000	9,300	2,900	6,600
Sweden	20.2	20.0	3,000	4,600	1,600	2,400
Venezuela	18.8	21.0	2,000	2,000	1,200	1,200
Other MEC 5/	67.9	68.0	4,800	12,100	2,200	6,200
China e/	88.6	96.0	9,000	9,000	3,500	3,500
U.S.S.R.	246.0	248.0	59,000	59,000	25,000	25,000
Other CPE 5/	15.1	15.0	900	900	300	300
World Total (may be rounded)	847.8	871.0	151,000	213,000	72,000	102,000

10. World Resources: World resources are estimated to exceed 800 billion long tons of crude ore containing more than 260 billion short tons of iron. U.S. resources are estimated at about 108 billion long tons of ore containing about 30 billion short tons of iron. U.S. resources are mainly low-grade taconite-type ores of the Lake Superior district that require beneficiation and agglomeration for commercial use. U.S. resources include economic reserves estimated at approximately 16 billion long tons of ore containing nearly 4 billion short tons of iron recoverable in concentrate.

11. Substitutes: Iron ore is the only source of primary iron. Small amounts of ferrous scrap may be added to blast furnace burdens. Scrap is extensively used in steelmaking and in iron and steel foundries.

IRON AND STEEL 1/

(Data in million short tons of metal, unless noted)

1. Domestic Production and Use: In 1987, the iron and steel and ferrous foundry industries produced steel mill products and castings valued at about $50 billion. The steel industry was composed of approximately 80 companies producing raw steel in 129 plants. Pig iron was produced by 15 companies owning 83 blast furnaces. Indiana, Ohio, Pennsylvania, Michigan, and Illinois accounted for about 70% of total raw steel production. The foundry industry included approximately 1,300 ferrous foundries producing gray, malleable, and ductile iron castings and steel castings. End use distribution of domestic iron and steel consumption in 1987 was estimated as follows: construction, 35%; transportation, 24%; machinery, 16%; appliances, 6%; and other, 19%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Pig iron:					
Production	48.8	52.0	50.0	44.3	47.0
Shipments 2/	49.1	52.2	50.0	44.4	47.0
Imports for consumption	0.2	0.7	0.3	0.3	0.3
Exports	3/	0.1	3/	3/	3/
Consumption, reported	50.1	53.2	51.4	45.6	47.0
Price, dollars per ton, Iron Age composite for year	213.00	213.00	213.00	213.00	213.00
Stocks, yearend, total producer and consumer	0.3	0.3	0.3	0.2	0.2
Steel and cast iron:					
Production of raw steel	84.6	92.5	88.3	81.6	87.0
Shipments: Steel mill products	67.6	73.7	73.0	70.3	74.0
Steel castings	0.7	0.9	0.9	0.8	1.0
Iron castings	9.0	10.2	9.2	8.7	8.2
Imports for consumption of major iron and steel products	18.0	27.5	25.7	21.9	21.0
Exports of major iron and steel products	1.6	1.4	1.3	1.2	1.4
Consumption, apparent	91.9	110.0	106.8	100.6	102.7
Price, finished base, cents per pound, Iron Age composite for year	26.2	27.3	27.6	24.8	25.0
Stocks, steel mill products, yearend; consumer and service center	11.1	12.0	4/9.9	5/5.7	5.8
Employment, average: 6/					
Blast furnaces and steel mills (SIC 3312)	277,000	265,000	235,000	208,000	200,000
Iron and steel foundries (SIC 332)	139,000	149,000	141,000	131,000	135,000
Net import reliance 7/ as a percent of apparent consumption	16	23	22	21	19

3. Recycling: See Iron and Steel Scrap.

4. Import Sources (1983-86): European Economic Community (EEC), 27%; Japan, 24%; Canada, 13%; Republic of Korea, 8%; other, 28%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Pig iron 8/	606.13	Free	$1.125/long ton
Structural steel	609.80	0.9% ad val.	2% ad val.

6. Depletion Allowance: Not applicable.

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e/ Estimated.
1/ See also Iron Ore and Iron and Steel Scrap.
2/ Includes pig iron transferred directly to steel furnaces at same site.
3/ Less than 50,000 tons.
4/ Revised series beginning in 1985.
5/ Service center stocks only beginning in 1986.
6/ Bureau of Labor Statistics.
7/ Defined as imports - exports + adjustments for Government and industry stock changes.
8/ Containing less than: Chromium, 0.2%; molybdenum, 0.1%; tungsten, 0.3%; and vanadium, 0.1%.

Prepared by Frederick J. Schottman, telephone number (202) 634-1022.

7. Government Stockpile: None.

8. Events, Trends, and Issues: Apparent consumption was little changed in 1987 compared with that of 1986. However, domestic production and shipments increased because of lower imports. Raw steel production began 1987 at about only 55% of capacity because the largest producer was shut down by a labor dispute. By late in the year, capacity utilization was about 85%. However, part of the increase in utilization resulted from the continuing decline in capability. Fourth quarter capability declined from 127 million tons per year in 1986 to 114 million tons per year in 1987. About 70% of the capacity was provided by integrated steel companies while the remainder was provided by nonintegrated producers including minimills and specialty steel companies.

The financial outlook for the steel industry improved but restructuring continued. Prices were generally higher because of firm demand, restrictions on imports, and the declining value of the dollar in international markets. Because of higher prices and shipments, and because of lower cost resulting from restructuring, most steel companies reported profits on their steel operations. However, the financial condition of many companies remained precarious because of debts and pension obligations. Two integrated steel companies remained in bankruptcy and a third company filed for bankruptcy in 1987. Following the settlement of a labor dispute, the largest domestic steel company announced that several plants would not reopen for the foreseeable future. One of the plants, which was said to be permanently closed, was later sold and reopened by new owners.

Imports of steel decreased again in 1987 as imports from most major steel exporting countries remained restricted by trade agreements. Special quotas and tariffs on speciality steels, which were to expire in July 1987, were extended until 1989 when the negotiated agreements on other steel products are scheduled to expire. The United States and Canada cooperated to prevent shipment of third-country steel through Canada to evade negotiated restrictions. The lower value of the dollar made foreign steel relatively more expensive and tended to reduce the amount of steel imported and to increase the price of imported steel.

Total world production increased slightly, but production in most industrialized countries remained far below capacity. Steel companies in Japan closed some older facilities to bring capacity more in line with foreseeable demand. The EEC tried to work out a cooperative program of plant closure to reduce overcapacity.

It is estimated that in 1988 domestic production of raw steel will be 82 million tons and U.S. apparent consumption of iron and steel will be 100 million tons.

9. World Pig Iron and Raw Steel Production:

	Pig Iron		Raw Steel	
	1986	1987 e/	1986	1987 e/
United States	44.3	47.0	81.6	87.0
European Economic Community	93.5	93.0	138.5	138.0
Japan	82.3	83.0	108.3	109.0
Other Market Economy Countries	102.7	106.0	138.7	143.0
China	55.3	61.0	57.4	63.0
U.S.S.R.	120.6	122.0	177.0	182.0
Other Centrally Planned Economies	48.1	49.0	79.5	81.0
World Total	546.8	561.0	781.0	803.0

10. World Resources: Not applicable. See Iron Ore.

11. Substitutes: Iron is the least expensive and most widely used metal. In most applications iron and steel compete either with less expensive nonmetallic materials or with more expensive materials having a property advantage. Iron and steel compete with lighter materials such as aluminum and plastics in the motor vehicle industry; with concrete, aluminum, and wood in construction; and with aluminum, glass, plastics, and paper in containers.

IRON AND STEEL SCRAP 1/

(Data in million short tons of metal, unless noted)

1. Domestic Production and Use: Total estimated value of 1987 domestic purchases (receipts of ferrous scrap by all domestic consumers from brokers, dealers, and other outside sources) and exports was $4.0 billion. The steel industry accounted for about 74% of the domestic scrap consumption, using scrap together with pig iron to produce steel products for the construction, transportation, oil and gas, machinery, container, appliance, and other consumer industries. The ferrous castings industry consumed about 25% of the total consumption to produce cast iron and steel products such as motor blocks, pipe, and machinery parts. Relatively small quantities were used for producing ferroalloys, for the precipitation of copper, and by the chemical industry; these uses totaled less than 1 million tons.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production: Home scrap	27.2	29.2	30.4	26.4	25.3
Purchased scrap 2/	41.3	45.0	48.4	49.3	54.2
Imports for consumption	0.6	0.6	0.6	0.7	0.8
Exports 3/	7.7	9.5	10.2	12.0	10.5
Consumption: Reported	61.8	65.7	70.5	65.9	69.0
Apparent	62.0	65.8	69.4	65.2	69.7
Price, average, dollars per gross ton 4/ delivered: No. 1 Heavy Melting composite price, Iron Age average: Pittsburgh, Philadelphia, Chicago	72.91	86.46	74.35	73.41	78.94
Stocks, consumer, yearend	5.8	5.3	5.1	4.3	4.4
Employment, dealers, brokers, processors e/	22,500	21,500	21,000	20,000	20,000
Net import reliance 5/ as a percent of apparent consumption	Net exporter				

3. Recycling: All iron and steel scrap is recycled material, consisting of about one-half home scrap, one-fourth prompt industrial scrap, and one-fourth old (obsolete) scrap.

4. Import Sources (1983-86): Canada, 88%; Mexico, 6%; United Kingdom, 1%; other, 5%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Iron and steel waste and scrap:			
Tin plate waste or scrap	606.08	Free	Free
Other:			
Not containing over 0.2% Cr, 0.1% Mo, 0.3% W, or 0.1% V	606.09	Free	75¢/long ton
Containing over 0.2% Cr, 0.1% Mo, 0.3% W, or 0.1% V	606.11	Free	0.5% ad val. plus additional duties

6. Depletion Allowance: Not applicable.

7. Government Stockpile: None.

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e/ Estimated.
1/ See also Iron Ore and Iron and Steel.
2/ Receipts minus shipments by consumers, plus exports minus imports.
3/ Includes rerolling material and ships, boats, and other vessels for scrapping.
4/ Gross ton = long ton = 2,240 pounds.
5/ Defined as imports - exports + adjustments for Government and industry stock changes.

Prepared by Raymond E. Brown, telephone number (202) 634-1752.

8. Events, Trends, and Issues: Through July 1987, raw steel production at 75.8% of productive capability was 49.4 million tons compared with 51.3 million tons at 68.4% of productive capability in the first 7 months of 1986. Total steel shipments through July 1987 were 42.9 million tons, compared with 42.7 million tons for the first 7 months of 1986. However, by the beginning of the fourth quarter, raw steel production increased substantially to about 85% of productive capability and total annual production for 1987 was estimated to have increased 6% from that of 1986. The domestic ferrous castings industry in the first 7 months of 1987 shipped 5.3 million tons of all types of iron castings, 19% more than in the same time period in 1986, while the 520,000 tons of steel castings shipments were slightly more than the 515,000 tons shipped in the first 7 months of 1986. On July 31, 1987, stocks of ferrous scrap held by the three major types of domestic consumers were 4.40 million tons, 229,000 tons less than on July 31, 1986. Composite prices quoted by Iron Age on a gross ton delivered basis of No. 1 Heavy Melting steel scrap to domestic purchasers in the first 9 months of 1987 averaged $78.94, ranging from $72.17 in April to $94.08 in September. In the first 9 months of 1986, this grade of scrap averaged $73.26, ranging from $75.50 in February to $70.90 in June.

For the first 7 months receipts of ferrous scrap by all domestic consumers from brokers, dealers, and other outside sources in 1987 were 23.4 million tons valued at $1.8 billion ($74.97 per ton) compared with 21.9 million tons valued at $1.6 billion ($71.88 per ton) in 1986.

In the first 7 months of 1987, the delivered cost of ferrous scrap received from brokers, dealers, and other outside sources by steel mills approximated $26 per ton of raw steel produced; manufacturers of steel castings paid approximately $136 per ton of castings shipped; and the iron castings industry paid approximately $73 per ton of castings shipped, excluding ingot molds and stools made using blast furnace hot metal.

Since spring, prices for scrap have risen significantly because of higher steel production, a larger share of steel production in electric furnaces, lower generation of home scrap because of increased continuous casting, and a decline of steel imports. This has resulted in a dwindling supply of high-quality scrap grades, especially those with low residuals.

Exports of all grades of ferrous scrap in the first 7 months of 1987 totaled 6.25 million tons valued at $525.0 million ($83.96 per ton) compared with 7.28 million tons valued at $662.9 million ($91.04 per ton) in the first 7 months of 1986.

The Institute of Scrap Iron and Steel, Inc. (ISIS), and the National Association of Recycling Industries, Inc. (NARI) merged their organizations into a single scrap industry trade association, the Institute of Scrap Recycling Industries (ISRI). The U.S. Department of Commerce released a report entitled "Trends In The U.S. Ferrous Scrap Industry" in June 1987. Another major U.S. Steel Company filed for protection under Chapter 11 of the Federal bankruptcy laws on April 17, 1987. The Environmental Protection Agency (EPA) published revised and stricter particulate-emission controls on July 1. In October, the U.S. Court of Appeals upheld a challenge to EPA's authority to regulate certain materials as "solid waste". ISRI submitted a written request to the Occupational Safety and Health Administration (OSHA) seeking to keep scrap processors classified as distributors but not as suppliers.

It is estimated that in 1988, domestic net receipts (all receipts minus shipments) of scrap plus exports will total 49.0 million tons and apparent U.S. consumption will be 66.0 million tons.

9. World Mine Production, Reserves, and Reserve Base: Not applicable.

10. World Resources: Not applicable.

11. Substitutes: Approximately 240,000 tons of direct-reduced iron, a potential substitute for iron and steel scrap, was used in the United States in 1987.

IRON AND STEEL SLAG 1/

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: In 1987, an estimated 18.5 million tons of iron and steel slags, byproducts of iron and steelmaking, valued at $115 million were sold or used. About 73% of this was iron slag with an f.o.b. value of $98 million, and the balance was steel slag with an f.o.b. value of $17 million. Iron blast furnace slags were processed at 34 facilities in 14 States and consisted of air cooled, expanded, and granulated types. Steel slags, from open hearth, basic oxygen, and electric furnaces, were processed at 60 facilities located in 26 States. About 67% of the Nation's iron and steel slags were produced in Pennsylvania, Indiana, Ohio, and Michigan. Iron and steel slags were mainly used as construction materials, with iron slag being typically used as road base, concrete aggregate, asphaltic concrete aggregate, and railroad ballast, comprising about 55%, 13%, 7%, and 6% of total end use, respectively, and steel slag being mainly used as road base, 45%; fill, 23%; and asphaltic concrete aggregate, 11%. Of all iron and steel slag products shipped, 88% traveled by truck with an average marketing range of 30 miles, 6% traveled by waterway with an average marketing range of 560 miles, and 5% traveled by rail with an average marketing range of 150 miles. The remaining 1% was used at plantsite.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production, marketable	18.386	22,063	21,078	21,068	18,500
Imports for consumption		Not available 2/			
Exports		Not available 2/			
Consumption: Apparent		Not available			
Estimated	18,386	22,063	21,078	21,068	18,500
Price, average value, dollars per ton, f.o.b. plant	4.31	4.66	4.95	5.25	6.20
Stocks, yearend		Not available			
Employment, processing plant e/	1,000	1,000	1,000	1,000	1,000
Net import reliance 3/ as a percent of apparent consumption		Not available			

3. Recycling: Before processing, some steel slag is recycled to blast furnaces, directly or as agglomerates, as a source of iron and flux materials. An estimated 3 million tons of steel slag was recycled to blast furnaces in 1987. Ferrous scrap, recovered from slag during processing, is also recycled to blast and steel furnaces.

4. Import Sources (1983-86): Not available. 2/ However, blast furnace slag is imported from and exported to Canada periodically. Minor amounts of basic slag were imported for use as artificial fertilizer.

5. Tariff: None.

6. Depletion Allowance: Not applicable.

7. Government Stockpile: None.

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e/ Estimated.
1/ See also Iron and Steel.
2/ Included in blanket Tariff Schedule categories.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.

Prepared by Donald P. Mickelsen, telephone number (202) 634-1023.

8. Events, Trends, and Issues: Sales and use of iron and steel slag dropped sharply from those of 1986. This was due to a shortage of iron slag availability at the beginning of the year and a continuing lack of acceptance for use of steel slag in state road bed construction specifications because of volume change problems. One large producer of iron blast-furnace slag was shut down until April by a major strike which caused a reduction in iron slag supplies. The average price of iron and steel slag sold in 1987 increased about 18%, reflecting higher processing costs involved in meeting more stringent user specifications.

   Essentially all iron slag produced is used, so availability of iron slag is largely dependent on current iron production. There are, however, large undetermined banks of steel slag yet to be worked, since high lime content and expandability problems have limited its use in the past. Today, with proper processing and aging, and improved technology, steel slag is accepted as a low-cost, high-friction aggregate. The construction industry continues to be the principle user of iron and steel slag. Iron slag is being used increasingly in bituminous mixtures and in lightweight concrete applications. Large increases are expected in the use of granulated blast furnace slag as a replacement for cement because of savings in natural resources and the energy required to manufacture cement clinker. Steel slag usage for concrete aggregate is also expected to be a major growth area.

9. World Mine Production, Reserves, and Reserve Base: Not applicable.

10. World Resources: Not applicable.

11. Substitutes: Sand, gravel, and crushed stone for construction materials are the predominant substitutes for iron and steel slags.

KYANITE AND RELATED MINERALS

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: One firm in Virginia, with integrated mining and processing operations, supplied all of the kyanite production. The material was from hard rock open pit mines. Synthetic mullite was believed to have been produced by four companies in Alabama, Georgia, Kentucky, and New York. It was estimated that 90% of the kyanite-mullite output was used in refractories--55% for smelting and processing ferrous metals, 20% for nonferrous metals, and 15% for glassmaking and ceramics. Nonrefractory uses accounted for the balance.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Mine	W	W	W	W	W
Synthetic mullite	e/23	e/27	e/27	W	W
Imports for consumption	NA	e/8	e/3	e/5	14
Exports e/	40	45	45	50	45
Shipments from Govt. stockpile excesses	None				
Consumption, apparent	W	W	W	W	W
Price: Domestic concentrate, from 35- to 325-mesh sizes, raw bulk, f.o.b. Georgia, $92 to $144 per ton, (bagged material $9 extra); imported kyanite, no current quotation; synthetic mullite, $150 to $1,500 per ton, depending upon type and grade.					
Stocks, producer	Not available				
Employment, kyanite mine and plant e/	200	200	200	200	150
Net import reliance 1/ as a percent of apparent consumption	Net exporter				

3. Recycling: Insignificant.

4. Import Sources (1983-86): Not available after 1977 from Bureau of the Census. Using non-Government sources, imports were estimated to be primarily andalusite from the Republic of South Africa.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Kyanite, sillimanite, andalusite, and dumortierite	523.81	Free	Free
Mullite	523.91	4.9% ad val.	30% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile: In addition to quantity shown below, the stockpile contained 1,047 tons of nonstockpile-grade material.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Kyanite, lump	-	0.1	-	-

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ See page 184 for definitions.
3/ Excludes the United States and Centrally Planned Economies.

Prepared by Michael J. Potter, telephone number (202) 634-1180.

8. Events, Trends, and Issues: U.S. production of kyanite was estimated to have decreased compared with that of 1986 owing to the closing of one of the two U.S. kyanite operations in late 1986. U.S. kyanite exports to Western Europe were believed to have been affected by the opening of a new kyanite operation in Sweden.

There continues to be a need for research in such areas as improved methods of ore beneficiation and quality control.

On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Apartheid Act of 1986, andalusite was certified by the U.S. Department of State as a strategic mineral essential for the economy or defense of the United States that is unavailable in adequate quantities from reliable and secure suppliers.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production e/		Reserves and Reserve Base 2/
	1986	1987	
United States	W	W	Large in the United States and the Republic of South Africa; assumed to be large in other countries.
France	57	60	
India	50	50	
South Africa, Republic of	205	200	
Other Market Economy Countries	8	10	
Centrally Planned Economies	NA	NA	
World Total 3/	321	320	

10. World Resources: Immense resources of kyanite and related minerals known are to exist in the United States. The chief resources are in deposits of micaceous schist and gneiss, mostly in the Appalachian area and in Idaho. These resources are not economical at present, but some may be eventually. The characteristics of kyanite resources in the rest of the world are believed to be similar to those in the United States.

11. Substitutes: Two types of synthetic mullite (fused and sintered), superduty fire clays, and high-alumina materials are substitutes for kyanite in refractories. Principal raw materials for synthetic mullite are bauxite, kaolin and other clays, and silica sand.

LEAD

(Data in thousand metric tons of lead, unless noted)

1. Domestic Production and Use: The value of mine production in 1987, based on the average U.S. producer price, was $254 million. Eight lead mines in Missouri plus lead-producing mines in Colorado, Idaho, and Montana yielded 99% of the total. The remainder was a byproduct from the mining of other commodities in Arizona, Illinois, New Mexico and New York. Primary lead was smelted and refined at two plants in Missouri, and one each in Montana and Nebraska. About 95% of secondary production came from 28 plants with annual capacities of 5,000 tons or more. Lead was consumed by about 280 firms. Transportation was the major end use with about 70% consumed in automotive batteries, gasoline additives, and other applications. Construction, communications, ammunition, electrical uses, TV glass, and paint represented 26%, with the balance used for ceramics, type metal, ballast or weights, and tubes or containers.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Mine, lead in concentrates	466	335	424	353	330
Primary refinery: From domestic ore	460	330	416	344	330
From imported materials 1/	55	66	71	22	30
Secondary refinery: Old scrap	452	586	570	566	630
Imports for consumption: Lead in concentrates	20	30	3	5	6
Exports: Lead in concentrates	20	12	10	4	1
Imports for consumption: Metal, wrought/unwrought	177	163	133	142	160
Exports: Metal, wrought/unwrought	20	7	27	13	10
Consumption: Reported	1,148	1,207	1,148	1,125	1,150
Apparent	1,136	1,152	1,131	1,134	1,130
Price, average, cents per pound: U.S.	21.7	25.6	19.1	22.0	36
London	19.3	20.1	17.8	18.4	26
Stocks, metal, producers/consumers, yearend	159	145	177	104	114
Employment: Mine and mill	3,200	2,200	2,000	1,500	1,200
Primary smelters/refineries	1,400	1,100	1,000	900	900
Secondary smelters/refineries	1,400	1,600	1,500	1,500	1,600
Net import reliance 2/ as a percent of apparent consumption	20	20	13	20	15

3. Recycling: Recovery of lead from scrap batteries was approximately 560,000 tons.

4. Import Sources (1983-86): Lead in concentrates--Peru, 66%; Honduras, 12%; Mexico, 7%; Canada, 4%; other, 11%.
Metal, wrought/unwrought--Canada, 59%; Mexico, 23%; Australia, 4%; Peru, 4%; other, 10%.
Total lead content--Canada, 54%; Mexico, 22%; Peru, 9%; Australia, 4%; other, 11%.

5. Tariff: In 1987, lead concentrates imported from Peru, Chile, and Mexico were duty free.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Concentrates	602.10	0.75¢/lb, lead content	1.5¢/lb, lead content
Unwrought lead	624.03	3/3.0% ad val., lead cont.	10.0% ad val., lead cont.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile:

		Stockpile Status--9-30-87		
Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Lead	998	545	-	-

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e/ Estimated.
1/ Included in imports for calculating net import reliance (see footnote 2).
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ Total rate not to be less than 1.0625¢/lb.
4/ See page 184 for definitions.

Prepared by William D. Woodbury, telephone number (202) 634-1083.

8. Events, Trends, and Issues: Domestic primary refinery capacity utilization was 60% in 1987, the lowest rate since 1968. Conversely, the utilization rate in the secondary sector was almost 90%, the highest ever recorded. Total domestic refined metal production therefore rebounded significantly from that of 1986, which was the second lowest level since 1968. Domestic mine production in 1987 declined to the lowest level since 1968, the year before the Viburnum Trend mines in Missouri achieved full production capabilities. A significant increase in world mine production occurred during 1987, however, mostly in Canada and China which were concentrate exporters. The U.S. and world lead reserve positions were reevaluated by the Bureau of Mines in the light of recent years of "high grading" in some mines owing to relatively low prices from 1982 through 1986. Two of the top ten battery manufacturers in the United States (one of which is also a small lead producer) merged individually with the number two and number three battery manufacturers. These two firms were also second and third in secondary lead production. This significant restructuring was necessary in order to forestall additional loss of secondary capacity, which stabilized in 1987.

The North American producer and London Metal Exchange (LME) average prices for lead, having risen steadily for the previous nine months of 1986, were about 28.75 and 23.25 cents per pound, respectively, at the beginning of 1987. Those prices declined about 2.75 and 1.25 cents per pound, respectively, during the first three months of the year. Starting in April, however, the U.S. price rose continually until July 7, when it reached 42 cents per pound where it held throughout the remainder of the year. The LME price rose to 33.5 cents per pound by the third week of May, but fell back and fluctuated between 27 and 31 cents per pound during the rest of the year, achieving a record differential spread of 15 cents per pound with the U.S. in October. This stimulated a high level of domestic imports in the last quarter of the year.

It is estimated that in 1988 domestic mine production of lead will be 380,000 tons and U.S. apparent consumption will be 1,130,000 tons. Future growth in lead use is contingent on the development of cost-competitive and reliable electric vehicles for general and new industrial uses, major power supply load-leveling applications, and continuing high growth of uninterruptible power supply systems.

At yearend, the Environmental Protection Agency (EPA) was in the final process of determining the regulatory framework and standards for lead smelting and refining wastes under the Resources Conservation and Recovery Act of 1976 as amended in 1980 and 1984. The proposed rulemaking could subject the primary lead industry to additional substantial costs. EPA was also considering modifying its leaching test for slag materials, which could favorably affect the industry.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States	353	330	11,000	22,000
Australia	435	435	16,000	28,000
Canada	304	400	8,000	15,000
Mexico	200	185	3,000	4,000
Peru	195	190	2,000	3,000
South Africa, Republic of	98	100	4,000	6,000
Yugoslavia	110	100	2,000	3,000
Other Market Economy Countries	655	640	9,000	14,000
Centrally Planned Economies	890	980	20,000	30,000
World Total	3,240	3,360	75,000	125,000

10. World Resources: In recent years, significant reserves of lead have been discovered associated with zinc and/or silver or copper ores in Alaska, Canada, Mexico, Australia, China, and the Republic of South Africa. The identified subeconomic lead resources of the world are estimated at about 1.4 billion tons, but the prospect for finding economic additional resources at a rate exceeding consumption is highly favorable.

11. Substitutes: Substitution by plastics has reduced the use of lead in building construction, electrical cable covering, and in cans and containers. Aluminum, tin, iron, and plastics compete with lead in other packaging and protective coatings, and tin has almost completely replaced lead in solder for new or replacement domestic potable water systems.

LIME 1/ 2/

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: In 1987, lime producers at 116 plants in 35 States sold or used 15.2 million tons of lime valued at $789 million, an increase of 5% in tonnage and 4% in value compared with that of 1986. Open-market sales increased 6% to 12.8 million tons. Captive lime used by producers was essentially unchanged at 2.4 million tons. Seventy-one companies produced lime. Ten companies, operating 29 plants, accounted for approximately 60% of the output. Principal producing States were Ohio, Missouri, Pennsylvania, Kentucky, Texas, and Alabama. Each produced over 1 million tons, and together accounted for approximately 60% of the output. The leading individual uses for lime were in steel furnaces, water treatment, construction, sulfur removal from stack gases, and paper and pulp. Production of dead-burned dolomite, used to make refractories, decreased 20%. Chemical and industrial sales increased 14%, construction sales decreased 5%, and agricultural sales decreased 26%.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production 3/	14,867	15,922	15,690	14,474	15,200
Imports for consumption	283	247	194	200	175
Exports	28	25	19	16	12
Consumption, apparent 4/	15,122	16,144	15,885	14,658	15,363
Price, dollars per ton at plant, average	50.96	50.95	51.56	52.59	51.91
Stocks, yearend		Not available			
Employment, mine and plant	5,300	5,500	5,500	5,400	5,400
Net import reliance 5/ as a percent of apparent consumption	2	1	1	1	1

3. Recycling: Large quantities of lime are regenerated by paper mills, carbide plants, and some municipal water treatment plants. Data for these plants are not included as production, in order to avoid duplication.

4. Import Sources (1983-86): Canada, 82%; Mexico, 18%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Hydrated	512.11	Free	6/12¢/100 lb
Other	512.14	Free	6/10¢/100 lb

6. Depletion Allowance: 14% (Domestic), 14% (Foreign), for limestone produced and used for lime production.

7. Government Stockpile: None.

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e/ Estimated.
1/ Data are for quicklime, hydrated lime, and refractory dead-burned dolomite.
2/ Excludes Puerto Rico, unless noted.
3/ Sold or used by producers.
4/ Stocks data are not available and stock changes are assumed to be zero for apparent consumption and net import reliance calculations.
5/ Defined as imports - exports + adjustments for Government and industry stock changes.
6/ Rates include weight of container.
7/ See page 184 for definitions.
8/ Includes Puerto Rico.

Prepared by Lawrence Pelham, telephone number (202) 634-1177.

8. Events, Trends, and Issues: Consumption of lime in most of its uses remained near 1986 levels. The 5% total increase in production was the result of a strike-free year for the steel industry and a slight improvement in the national economy. Producers awaited clean air or acid rain legislation that would require removing sulfur from powerplant stack gases and result in a dramatic increase in lime demand. It is estimated that in 1988, domestic production of lime will be 15.0 million tons and U.S. apparent consumption will be 15.1 million tons.

The lime industry is energy intensive. About 78% of the industry used coal, 14% used natural gas, and 8% used petroleum coke and oil. Current trends indicate a preference for coal in future lime plants.

9. World Lime Production, and Limestone Reserves and Reserve Base:

	Production		Reserves 7/	Reserve Base 7/
	1986	1987 e/		
United States 8/	14,498	15,200		
Belgium	1,980	2,000		
Brazil	5,700	5,700		
Canada	2,600	2,600	Adequate for all countries listed	
France	3,200	3,200		
Germany, Federal Republic of	7,820	7,800		
Italy	2,300	2,300		
Japan	7,404	8,000		
Mexico	4,400	4,400		
United Kingdom	2,750	2,800		
Yugoslavia	2,750	2,800		
Other Market Economy Countries	14,022	14,000		
Czechoslovakia	3,530	3,500		
German Democratic Republic	3,900	3,900		
Poland	4,500	4,500		
Romania	4,100	4,100		
U.S.S.R.	32,190	32,200		
Other Centrally Planned Economies	4,187	4,200		
World Total (may be rounded)	121,831	123,000		

10. World Resources: Domestic and world resources of limestone and dolomite suitable for lime manufacture are adequate.

11. Substitutes: Limestone is a substitute for lime for many uses such as agriculture, fluxing, and sulfur removal. Limestone contains less reactive material, is slower to react, and may have other major disadvantages to lime depending on the use; however, limestone is considerably less expensive than lime. Calcined gypsum is an alternate material in industrial plasters and mortars. Cement and lime kiln dust and fly ash are potential resources as substitutes for some construction uses of lime.

LITHIUM

(Data in short tons of contained lithium, unless noted)

1. Domestic Production and Use: The United States continued as the largest producer and consumer of lithium minerals and compounds worldwide. The value of domestic production was estimated to be about $65 million in 1987. Two companies produced lithium compounds for domestic consumption as well as for export to other market economy countries.

   The ceramics and glass industry, the largest consumer of lithium, used lithium in the form of lithium carbonate or ore concentrates and accounted for almost 40% of domestic consumption. Other major uses, accounting for an additional 45% of consumption of lithium, were in primary aluminum production and the manufacture of lubricants and greases.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production	W	W	W	W	W
Imports for consumption	35	90	410	700	900
Exports	2,600	2,900	2,500	2,000	2,000
Consumption: Apparent	W	W	W	W	W
Estimated 1/	2,200	3,200	2,500	2,600	2,700
Price, yearend, dollars per pound:					
Lithium carbonate	1.48	1.54	1.50	1.50	1.55
Lithium hydroxide monohydrate	1.93	1.93	1.93	1.93	1.97
Stocks, producer, yearend	W	W	W	W	W
Employment, mine and mill e/	300	300	275	265	230
Net import reliance 2/ as a percent of apparent consumption	Net exporter				

3. Recycling: Insignificant.

4. Import Sources (1983-86): Chile, 59%; Zimbabwe, 23%; Canada, 7%; Australia, 3%; other, 8%. Imports have increased and exports have decreased as domestic production has declined and new sources of inexpensive imports have been developed.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Mineral concentrates	523.81	Free	Free
Metal	415.30	6.6% ad val.	25% ad val
Salts	426.46	5.0% ad val.	25% ad val.
Compounds	419.10	3.7% ad val.	25% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Based primarily on monitoring at the concentrate stage and assuming a 15% lithium loss during conversion of concentrate to chemicals.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.
4/ These estimates denote only an approximate order of magnitude, no basis for more exact estimates is available. Output by China and the U.S.S.R. has never been reported.
5/ Excludes U.S. production.
6/ Excludes Argentina, Namibia, Portugal, China, and U.S.S.R.

Prepared by Joyce A. Ober, telephone number (202) 634-1177.

8. Events, Trends, and Issues: Exploration and evaluation continued on proposed brine operations in South America. New lithium brine developments were considered for deposits in Argentina, Bolivia, and Chile. Completion of any of these projects would contribute additional capacity to an industry already faced with excess production capacity worldwide.

Major U.S. and foreign aluminum producers began marketing aluminum-lithium alloys. Most major aircraft manufacturers announced plans for application of these alloys in their newly designed airliners. Increased application of aluminum-lithium alloys necessitated development of safer and more efficient handling and recycling of alloy scrap.

Lithium batteries made their first appearance in the consumer marketplace in 1987. This market, although a relatively small share of total lithium consumption, was expected to grow significantly. Research continued in the use of rechargeable lithium batteries to power electric vehicles.

It is estimated that in 1988, U.S. consumption will be about 2,800 tons of contained lithium, with imports becoming a more important source.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States	W	W	400,000	450,000
Argentina e/	1	1	NA	NA
Australia e/	382	400	410,000	480,000
Bolivia	-	-	-	6,000,000
Brazil	42	40	1,000	NA
Canada	17	150	200,000	400,000
Chile	932	1,000	1,400,000	1,500,000
Namibia e/	70	70	NA	NA
Portugal	15	15	NA	NA
Zaire	-	-	-	350,000
Zimbabwe	620	700	25,000	30,000
China 4/	500	500	NA	NA
U.S.S.R. 4/	1,800	1,800	NA	NA
World Total (may be rounded)	5/4,379	5/4,700	6/2,400,000	6/9,200,000

10. World Resources: The identified lithium resources total 0.86 million tons in the United States and 13.1 million tons in other market economy countries.

11. Substitutes: Substitutes for lithium compounds are possible in manufactured glass, ceramics, greases, and batteries. Examples are sodic and potassic fluxes in ceramics and glass manufacture; calcium and aluminum soaps as substitutes for lithium stearates in greases; and zinc, magnesium, calcium, and mercury as anode material in primary batteries. Lithium carbonate is not considered an essential ingredient in aluminum potlines. Substitutes for aluminum-lithium alloys as structural materials are composite materials consisting of glass, aramid, or boron fibers in engineering resins.

MAGNESIUM METAL 1/

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use:** In 1987, primary magnesium metal, valued at over $410 million, was produced by three companies in Texas, Utah, and Washington. The firm in Washington used the silicothermic method to produce magnesium from dolomite, while the other two companies produced magnesium by electrolytic processes from magnesium chloride recovered from sea water and lake brines. The company in Texas used seawater as a raw material, and the company in Utah used brines from the Great Salt Lake. Fifty-three percent of the metal was used for the manufacture of aluminum-based alloys. Magnesium castings and wrought products accounted for 23%; cathodic protection, 9%; reducing agent, 7%; manufacture of nodular cast iron, 2%; and other uses, 6%.

2. **Salient Statistics—United States:**

Salient Statistics—United States:	1983	1984	1985	1986	1987 e/
Production: Primary	115	159	150	138	135
Secondary	46	48	46	46	46
Imports for consumption	6	9	9	9	12
Exports	47	48	40	44	46
Consumption: Reported, primary	82	90	84	77	90
Apparent	117	140	137	128	130
Price, dollars per pound	1.38	1.43-1.48	1.48-1.53	1.53	1.53
Stocks, producer and consumer, yearend	28	35	35	35	32
Employment e/	500	500	500	450	450
Net import reliance 2/ as a percent of apparent consumption	Net exporter				

3. **Recycling:** In 1987, about 26,000 tons of the secondary production was recovered from old scrap.

4. **Import Sources (1983-86):** Norway, 36%; Canada, 23%; France, 8%; United Kingdom, 7%; other, 26%.

5. **Tariff:**

Tariff:	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Unwrought metal	628.55	8.0% ad val.	100% ad val.
Unwrought alloys	628.57	6.5% ad val.	60.5% ad val.
Wrought metal	628.59	4.5¢/lb on Mg content + 2.5% ad val.	40¢/lb on Mg content + 20.0% ad val.

6. **Depletion Allowance:** Dolomite 14% (Domestic and Foreign); magnesium chloride 5% (Domestic and Foreign).

7. **Government Stockpile:** None.

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e/ Estimated.
1/ See also Magnesium Compounds.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.

Prepared by Deborah A. Kramer, telephone number (202) 634-1083.

8. Events, Trends, and Issues: With strong demand in aluminum alloying and increased use of die-cast magnesium components, demand for magnesium remained strong. In response to this demand, the largest domestic primary magnesium producer announced that it was increasing the operating capacity at its Freeport, TX, plant. The second largest U.S. producer, whose feedstock was destroyed when its solar evaporation ponds were flooded in June 1986, reportedly planned to continue operating using brine from a planned pumping station in Utah's west desert area. The pumping station was expected to be completed by 1988. Until that time, the primary magnesium facility planned to continue operating at reduced levels by using purchased brine.

Development continued on new plant construction and plant expansions outside the United States. A joint venture between Monaco-based and U.S.-based concerns to construct a 55,000-ton-per-year primary magnesium facility in Alberta, Canada, was dissolved in October 1986, when the U.S. firm pulled out. But, the Monaco-based firm then formed a joint venture with a Canadian natural resources company to construct a larger scale plant. The first phase, with an annual capacity of 14,000 tons, was expected to be completed by 1989; total plant capacity of 69,000 tons per year was planned for completion by 1993. In May 1987, construction began on a 66,000-ton-per-year primary magnesium facility in Quebec, Canada. Completion is expected by 1989. Although a plant expansion of 6,500 tons per year was completed at the primary magnesium plant in Brazil in early 1987, a second expansion of 10,000 tons per year, originally scheduled for completion in July 1987, was delayed because of problems with equipment deliveries and construction of a new power transmission line to the plant.

9. World Production, Reserves, and Reserve Base:

	Production	
	1986	1987 e/
United States	138	135
Brazil	3	5
Canada	8	10
France	15	15
Italy	14	15
Japan	9	10
Norway	61	65
Yugoslavia	5	5
China	8	8
U.S.S.R.	98	100
World Total	359	368

Reserves and Reserve Base 3/

Since domestic magnesium metal production is derived from natural brines and dolomite, the reserves and reserve base for this metal are sufficient to supply current and future requirements. To a limited degree the existing natural brines may be considered a renewable resource wherein any magnesium removed by man can be renewed by nature in a short span of time.

10. World Resources: Resources from which magnesium metal may be recovered range from large to virtually unlimited and are globally widespread. Resources of dolomite, and magnesium-bearing evaporite minerals are enormous; magnesium-bearing brines are estimated to constitute a resource in billions of tons; and magnesium can be recovered from seawater at places along world coast lines where salinity is highest.

11. Substitutes: Aluminum and zinc may be substituted for magnesium castings and wrought products.

MAGNESIUM COMPOUNDS 1/

(Data in thousand short tons of magnesium content, unless noted)

1. Domestic Production and Use: Magnesium compound production and demand remained at essentially the same levels as those of 1986. Total production was valued at approximately $185 million. Magnesium oxide and other compounds were recovered from seawater by six companies in California, Delaware, Florida, and Texas; from well brines by three companies in Michigan; and from lake brines by two companies in Utah. Magnesite was mined by one company in Nevada, and olivine was mined by two companies in North Carolina and Washington. Natural brines continued to be the dominant source of magnesium compounds, with about 65% recovered from seawater and well and lake brines. Almost 70% of the consumption of magnesium compounds was for the manufacture of basic refractories used in high-temperature metallurgical furnaces. The remainder was used to prepare caustic-calcined and specified magnesias.

2. Salient Statistics—United States:

Salient Statistics—United States:	1983	1984	1985	1986	1987 e/
Production	607	633	464	454	450
Imports for consumption	67	126	148	176	180
Exports	17	30	28	28	20
Consumption, apparent	657	729	584	602	610
Stocks, producer, yearend		Not available			
Employment, plant	900	850	800	750	750
Net import reliance 2/ as a percent of apparent consumption	8	13	21	25	26

3. Recycling: None.

4. Import Sources (1983-86): Greece, 27%; Canada, 22%; China, 16%; Ireland, 10%; other, 25%.

5. Tariff: 3/

Tariff: 3/	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude magnesite	522.61	Free	$10.50/ton
Caustic-calcined magnesite	522.64	$2.10/ton	$21.00/ton
Refractory magnesia (containing not over 4% lime)	531.01	0.16¢/lb	0.75¢/lb
Refractory magnesia (containing over 4% lime)	531.04	6.0% ad val.	30.0% ad val.

6. Depletion Allowance: Brucite 10% (Domestic and Foreign); dolomite and magnesium carbonate 14% (Domestic and Foreign); magnesium chloride 5% (Domestic and Foreign); and olivine 22% (Domestic) and 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ See also Magnesium Metal.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ Tariffs are based on gross weight.
4/ See page 184 for definitions.
5/ Excludes the United States.

Prepared by Deborah A. Kramer, telephone number (202) 634-1083.

8. Events, Trends, and Issues: Import reliance for magnesium compounds remained at the high level it has been for the past 2 years. Domestic production remained at a low level as imports continued to supply a significant share of U.S. demand. The market for refractories, the largest use for magnesium compounds, continued to shrink because of the development of longer life refractories and changes in iron and steel production techniques.

In 1987, plans were announced to mine magnesite from a deposit in Washington, with estimated reserves of 880,000 tons of magnesia. In addition, interest in magnesite continued outside the United States as new deposits were evaluated in Australia, China, Pakistan, and Spain, and construction of new magnesia plants was planned in France and Israel.

9. World Production, Reserves, and Reserve Base:

	Magnesite Production		Magnesite Reserves and Reserve Base 4/	
	1986	1987 e/	Reserves	Reserve Base
United States	W	W	10,000	15,000
Austria	404	400	15,000	20,000
Brazil	81	80	50,000	70,000
Greece	288	300	30,000	35,000
India	133	130	30,000	50,000
Spain	222	230	10,000	30,000
Turkey	317	320	71,000	173,000
Yugoslavia	127	130	5,000	10,000
Other Market Economy Countries	204	200	450,000	510,000
China	634	635	820,000	1,150,000
Czechoslovakia	213	220	20,000	30,000
Korea, North	604	600	490,000	820,000
U.S.S.R.	692	700	720,000	800,000
Other Centrally Planned Economies	5	5	10,000	15,000
World Total (may be rounded)	5/3,900	5/3,950	2,731,000	3,728,000

In addition to magnesite, there are vast reserves of well and lake brines and seawater from which magnesium compounds may be recovered.

10. World Resources: Resources from which magnesium compounds may be recovered range from large to virtually unlimited and are globally widespread. Identified world resources of magnesite total 12 billion tons, and of brucite, several million tons. Resources of dolomite, forsterite, and magnesium-bearing evaporite minerals are enormous; magnesia-bearing brines are estimated to constitute a resource in billions of tons; and magnesium hydroxide can be recovered from seawater at places along world coast lines where salinity is highest.

11. Substitutes: Alumina, silica, and chromite can be substituted for magnesia in some refractory applications.

MANGANESE

(Data in thousand short tons, gross weight, unless noted)

1. Domestic Production and Use: No manganese ore containing 35% or more manganese was domestically produced in 1987. Most manganese ore was consumed by about 20 firms with plants located principally in the Eastern and Midwestern United States. A large share of this ore was upgraded to ferroalloys and metal for use in steel production. Most of the remaining ore was used in producing pig iron and dry cell batteries, and for various chemical purposes. End uses were construction, 20%; transportation, 13%; machinery, 9%; and other, 58%.

2. Salient Statistics--United States: 1/

	1983	1984	1985	1986	1987 e/
Production, mine 2/			None		
Imports for consumption:					
Manganese ore	368	338	387	463	325
Ferromanganese	342	409	367	396	290
Exports: Manganese ore	19	238	56	42	60
Ferromanganese	8	7	7	4	3
Shipments from Govt. stockpile					
excesses: 3/ Manganese ore	74	65	191	150	220
Ferromanganese	-	(24)	-	(81)	-
Consumption, reported: 4/					
Manganese ore	531	615	e/545	e/500	540
Ferromanganese	446	492	466	376	450
Consumption, apparent, manganese 5/	668	627	698	730	690
Price, average value, 46%-48% Mn metallurgical ore, dollars per L.T.U. cont. Mn, c.i.f. U.S. ports	1.38	1.42	1.43	1.34	1.27
Stocks, producer and consumer, yearend:					
Manganese ore	617	582	e/589	e/455	300
Ferromanganese	195	159	100	93	75
Net import reliance 6/ as a percent of apparent consumption	99	98	100	100	100

3. Recycling: Scrap recovery specifically for manganese was insignificant. However, considerable manganese was recycled through processing operations as a minor component of ferrous and nonferrous scrap and steelplant slag.

4. Import Sources (1983-86): 1/
   Manganese ore - Gabon, 43%, Brazil, 24%; other, 33%.
   Ferromanganese - Republic of South Africa, 33%; France, 29%; other, 38%.
   Manganese contained in all manganese imports - Republic of South Africa, 25%; France, 14%; Gabon, 14%; Brazil, 13%; other, 34%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrate	601.27	Free	1¢/lb. of contained Mn
High-carbon ferromanganese	606.30	1.5% ad val.	10.5% ad val.
Metal	632.30	14% ad val.	20% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

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e/ Estimated.
1/ Manganese content typically ranges from 35% to 54% for manganese ore and from 74% to 95% for ferromanganese.
2/ Excludes manganiferous ore containing less than 35% manganese, which accounts for about 2% or less of apparent consumption of manganese.
3/ Net quantity including effect of stockpile upgrading program. Data in parentheses denote stockpile acquisitions.
4/ Total manganese consumption cannot be approximated from consumption of manganese ore and ferromanganese because of the use of ore in making manganese ferroalloys and metal.
5/ Thousand short tons, manganese content. Based on estimates of average content for all significant components except imports for which content is reported.
6/ Defined as imports - exports + adjustments for Government and industry stock changes.
7/ Thousand short tons, manganese content; see page 184 for definitions.

Prepared by Thomas S. Jones, telephone number (202) 634-7091.

7. Government Stockpile: Data tabulated below pertain to uncommitted inventories of stockpile-grade material. The stockpile contained further small quantities of natural battery ore, chemical ore, and metallurgical ore that had been sold but not yet shipped, and for these kinds of ore also about 34,000 tons, 90 tons, and 919,000 tons, respectively, of nonstockpile-grade material. At midyear, the General Services Administration contracted through 1988 for upgrading 214,700 tons of metallurgical manganese ore in the stockpile into 116,600 tons of high-carbon ferromanganese. Of these 2-year totals, 109,000 tons of ore was to be converted in 1987 and 105,700 tons in 1988.

Stockpile Status--9-30-87

Material		Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Battery:	Natural ore	62	172	14	-
	Synthetic dioxide	25	3	-	-
Chemical ore		170	172	-	-
Metallurgical ore		2,700	2,139	-	-
Ferromanganese:	High-carbon	439	705	-	-
	Medium-carbon	-	29	-	-
Silicomanganese		-	24	-	-
Electrolytic metal		-	14	-	-

8. Events, Trends, and Issues: The price of metallurgical ore receded on international markets for the second consecutive year, whereas prices for ferroalloys and metal rose in the United States. U.S. imports of manganese in all forms were the lowest since before World War II, absent a yearend increase. On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Apartheid Act of 1986, manganese was certified by the U.S. Department of State as a strategic mineral essential for the economy or defense of the United States that is unavailable in adequate quantities from reliable and secure suppliers.

It is estimated that in 1988 domestic mine production of manganese ore 2/ will be zero, and U.S. apparent consumption of manganese will be 710,000 tons, content basis. The majority of total U.S. demand will be supplied by manganese imports in both ore and upgraded forms.

Manganese is an essential element for man and animals that can be harmful when in excess. Thus, manganese can be an industrial poison, but is not a hazard generally. The Environmental Protection Agency found as of August 1985 that ambient air concentrations of manganese posed no significant risk to public health, so that regulation directed specifically at manganese was unnecessary under the Clean Air Act.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 7/	Reserve Base 7/
	1986	1987 e/		
United States	-	-	-	-
Australia	1,818	1,800	75,000	168,000
Brazil	e/2,976	3,000	20,900	69,000
Gabon	2,767	2,500	110,000	190,000
India	1,433	1,400	20,000	30,000
Mexico	e/506	525	3,700	8,600
South Africa, Republic of	4,100	3,500	407,000	2,900,000
Other Market Economy Countries	e/480	480	Small	Small
China	e/1,760	1,760	15,000	32,000
U.S.S.R.	e/10,700	10,700	325,000	500,000
Other Centrally Planned Economies	e/180	190	Small	Small
World Total (rounded)	e/26,700	25,900	1,000,000	3,900,000

10. World Resources: Identified land-based resources are large but are irregularly distributed. The U.S.S.R. and the Republic of South Africa account for more than 80% of the world's identified resources; the Republic of South Africa for more than 75% of those of the market economy countries. Extensive accumulations of manganese as oxide nodules on ocean floors and as oxide crusts at shallower depths may have future commercial significance.

11. Substitutes: There is no satisfactory substitute for manganese in its major applications.

MERCURY

(Data in 76-pound flasks of mercury content, unless noted)

1. Domestic Production and Use: Production of mercury in 1987 came solely as a byproduct from six gold mining operations, of which five were located in Nevada and one in Utah. About five companies in the Eastern United States recovered secondary mercury from wornout or obsolete items and waste products, such as dental amalgams, batteries, and instruments. It was also retrieved for recycling from operating chlorine and caustic soda plants and from U.S. Department of Energy stocks of mercury. The value of reported mercury consumption was estimated at $12.9 million, based on the average annual price of $300 per flask. About 200 companies, universities, and Government facilities located east of the Mississippi River accounted for an estimated 90% of the Nation's mercury consumption. End-use distribution in 1987 was estimated as follows: electrical, 51%; electrolytic production of chlorine and caustic soda, 19%; paints, 11%; industrial and control instruments, 7%; and other, 12%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Mine production	25,070	19,048	16,530	W	W
Secondary production:					
Industrial	13,751	5,673	5,358	6,362	7,500
Government 1/	-	-	585	3,078	3,000
Imports for consumption	12,786	25,327	18,890	20,187	21,000
Exports		Not available			
Shipments from Govt. stockpile excesses	6,000	4,092	4,534	463	3,700
Consumption: Reported	49,138	54,669	49,846	45,946	43,000
Apparent	55,416	57,903	45,167	W	W
Price, average value, dollars per flask: New York, dealer	322.44	314.38	310.96	232.79	300.00
London	313.33	306.40	288.56	193.80	250.00
Stocks: Mine, consumer and dealer, yearend	31,018	27,255	27,985	2/7,189	2/8,000
Employment, mine and mill, average	45	41	35	22	10
Net import reliance 3/ as a percent of apparent consumption	30	57	50	W	W

3. Recycling: Production from old scrap totaled 7,500 flasks, equivalent to 17% of reported consumption.

4. Import Sources (1983-86): Spain, 37%; Algeria, 17%; Turkey, 14%; China, 10%; other, 22%.

5. Tariff: In 1987, mercury, and mercury-bearing waste and scrap imported from Brazil, Hong Kong, and Turkey were duty free.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Metal, and waste and scrap	632.34	6.4¢/lb	25¢/lb

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile: In addition to the data shown below, 28,739 flasks of secondary mercury was held by the U.S. Department of Energy in Oak Ridge, TN.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Mercury	10,500	165,526	-	3,700

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Surplus secondary mercury released from U.S. Department of Energy stocks.
2/ Excludes mine stocks in order to avoid disclosing company proprietary data.
3/ Defined as imports - exports + adjustments for Government and industry stock changes. Export data were not available and were assumed to be zero in the calculation.
4/ See page 184 for definitions.
5/ Excludes U.S. production.

Prepared by Linda C. Carrico, telephone number (202) 634-1125.

8. Events, Trends, and Issues: World mine production decreased for the second consecutive year owing to depressed international prices and the closure of the only U.S. mercury mine. Spanish, Algerian, and Turkish officials met periodically during the year to review the weak market conditions and to try to bolster mercury prices. Some producers decided to set floor prices above the market price and suspend spot sales throughout most of the year. With floor prices well above the average monthly U.S. and London prices, consumers' interest in primary material weakened.

In early January, the only domestic mercury mine, located in McDermitt, NV, closed, but continued sales obligations from stocks on hand. The closure was in response to increased low-cost imports over the past 4 years and sales of excess mercury from U.S. Government stockpiles. A significant amount of byproduct mercury was recovered from an open pit gold mine near Gabbs, NV.

The price of primary mercury increased gradually during most of the year owing to the setting of floor prices and the suspension of spot sales, which caused tight supplies. As reported in Metals Week, the average monthly New York dealers' price for primary mercury was $217.25 per flask in January, and increased to $313.00 per flask in May; thereafter, it fell slightly in June to $307.27 per flask and again in July to $295.65 per flask. Signs of recovery were evident in August and September when the average price increased to $313.33 per flask and $342.14 per flask, respectively. The average monthly London price showed a similar pattern during the year. The price increased gradually during the first 5 months of the year, from a low of $165.56 per flask in January, to $272.17 per flask in May, and then declined in June and July to $257.78 per flask and $238.89 per flask, respectively. The August average jumped almost $28.00 to $266.56 per flask and increased in September to $302.38 per flask, the highest monthly average since December 1984.

During fiscal year 1987, the General Services Administration (GSA) sold 2,901 flasks and shipped 2,903 flasks of excess secondary mercury from U.S. Department of Energy stocks in Oak Ridge, TN. GSA was authorized on November 14, 1986, to dispose of 3,700 flasks of excess primary mercury from the National Defense Stockpile. During January through June 1987, GSA sold and shipped the 3,700 flasks authorized for disposal.

Bureau of Mines estimates of mercury reserves in the United States, Algeria, and Spain were modified from previously published estimates to reflect current information on each deposit.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States	W	W	100,000	120,000
Algeria	23,000	20,000	60,000	90,000
Italy	-	-	-	2,000,000
Mexico	10,000	10,000	150,000	250,000
Spain	42,000	42,000	2,200,000	2,600,000
Turkey	6,000	7,000	-	190,000
Other Market Economy Countries	4,420	5,000	390,000	700,000
U.S.S.R.	66,000	66,000	300,000	500,000
Other Centrally Planned Economies	24,400	24,000	300,000	500,000
World Total (may be rounded)	5/175,820	5/174,000	3,500,000	7,000,000

10. World Resources: World mercury resources are estimated at 17 million flasks, located principally in Spain, the U.S.S.R., Yugoslavia, and Italy. At present production rates, sufficient resources are available for about 98 years.

11. Substitutes: Present and potential mercury substitutes include lithium, zinc air, or nickel-cadmium cells in batteries; diaphragm and membrane cells in the electrolytic production of chlorine and caustic soda; composite materials for dental fillings; and various compounds in exterior latex paint.

MICA (NATURAL), SCRAP AND FLAKE 1/

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: Scrap and flake mica production, excluding low-quality sericite, increased about 9% in 1987. North Carolina accounted for about 60% of U.S. production. The remaining output came from Connecticut, Georgia, New Mexico, Pennsylvania, South Carolina, and South Dakota. Scrap mica was recovered principally from mica and sericite schist and from feldspar, kaolin, and lithium beneficiation. The bulk of domestic production was processed into small particle-size mica by wet and dry grinding. Primary uses were joint cement, paint, roofing, oil well drilling, and rubber products. The value of 1987 scrap mica production was $7.8 million. Ground mica sales were valued at $28 million. There were 12 domestic producers of scrap and flake mica. Production of low-quality sericite, used primarily for brick manufacturing, totaled 37,000 tons, valued at $133,000.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production 2/ 3/, mine	140	161	138	148	162
ground	130	146	136	127	150
Imports for consumption e/	7	12	10	11	11
Exports e/	10	8	9	7	7
Consumption, apparent 4/	127	150	137	131	154
Price, average, dollars per ton, reported:					
Scrap and flake	46	44	46	48	49
Ground:					
Wet	397	392	407	419	420
Dry	118	123	130	140	140
Stocks, producer, yearend e/	7	7	7	7	7
Employment, mine e/	75	80	80	80	80
Net import reliance 5/ as a percent of apparent consumption	E	3	1	3	3

3. Recycling: None.

4. Import Sources (1983-86): Canada, 59%; India, 38%; other, 3%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Phlogopite, untrimmed	516.11	Free	15.0% ad val.
Phlogopite, waste and scrap valued under 5¢/lb	516.21	4.2% ad val.	25.0% ad val.
Other waste and scrap valued under 5¢/lb	516.24	2.4% ad val.	25.0% ad val.
Other mica, unmanufactured	516.41	Free	4¢/lb
Ground or pulverized	516.81	2.4% ad val.	20.0% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. E Net exporter.
1/ See also Mica (Natural), Sheet.
2/ Sold or used by producing companies.
3/ Excludes low-quality sericite used primarily for brick manufacturing.
4/ Based on ground mica.
5/ Defined as imports - exports + adjustments for Government and industry stock changes.
6/ See page 184 for definitions.

Prepared by Lawrence L. Davis, telephone number (202) 634-1206.

8. Events, Trends, and Issues: The United States remained the major producer of scrap and flake mica in 1987. Imported mica is used primarily for making mica paper and as a filler and reinforcer in plastics. It is estimated that in 1988 domestic mine production of scrap and flake mica will be 160,000 tons and U.S. apparent consumption of ground mica will be 150,000 tons.

   The principal environmental impact of mica mining was the land disturbance commonly associated with surface mining.

9. World Mine Production and Reserve Base:

	Production		Reserves 6/	Reserve Base 6/
	1986	1987 e/		
United States 2/	148	162	Large	Large
Canada	13	15	Large	Large
India	21	20	Large	Large
Other Market Economy Countries	40	40	Moderate	Moderate
Centrally Planned Economies	56	55	Large	Large
World Total	278	292	Large	Large

10. World Resources: Resources of scrap and flake mica are available in granite, pegmatite, schist, and clay deposits and are considered more than adequate to meet anticipated world demand in the foreseeable future.

11. Substitutes: Some of the lightweight aggregates such as diatomite, vermiculite, and perlite may be substituted for ground mica when used as a filler. Ground synthetic fluorophlogopite, a fluorine-rich mica, may replace natural ground mica for uses that require the thermal and electrical properties of mica.

MICA (NATURAL), SHEET 1/

(Data in thousand pounds, unless noted)

1. **Domestic Production and Use:** A minor amount of sheet mica, estimated at less than 500 pounds, was produced in 1987. The domestic consuming industry was dependent upon imports and shipments of Government stockpile excesses to meet demand. During 1987, an estimated 2.3 million pounds of sheet mica valued at $2.1 million was consumed by 16 companies in 9 States mainly in the East and Midwest. Most was fabricated into parts for electronic and electrical equipment.

2. **Salient Statistics--United States:**

	1983	1984	1985	1986	1987 e/
Production, mine e/	2/	2/	2/	2/	2/
Imports for consumption	2,634	2,336	2,662	3,972	4,500
Exports e/	1,210	1,914	1,667	2,147	2,200
Shipments from Govt. stockpile excesses	256	1,711	1,737	-	150
Consumption, apparent	2,207	2,439	2,425	2,276	2,300
Price, average value, dollars per pound, muscovite mica, reported:					
Block	13.06	13.57	14.68	19.52	19.60
Film	5.18	5.40	3.79	4.91	4.90
Splittings	0.60	0.71	0.64	0.52	0.60
Stocks, fabricator and trader, yearend e/	4,074	3,768	4,075	3,624	3,774
Employment, mine			None		
Net import reliance 3/ as a percent of apparent consumption	100	100	100	100	100

3. **Recycling:** None.

4. **Import Sources (1983-86):** India, 60%; Belgium, 25%; Japan, 4%; France, 3%; other, 8%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Phlogopite, untrimmed	516.11	Free	15% ad val.
Split block	516.31	Free	Free
Other mica, unmanufactured	516.41	Free	4¢/lb
Splittings	516.51	Free	Free
Film not cut/stamped	516.61	Free	Free
Film cut/stamped	516.71	4.4% ad val.	45% ad val.
Block cut/stamped, not perforated, indented	516.73	5% ad val.	40% ad val.
Block cut, other forms	516.74	8% ad val.	40% ad val.
Block cut, perforated, indented	516.76	5% ad val.	40% ad val.

6. **Depletion Allowance:** 22% (Domestic), 14% (Foreign).

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e/ Estimated.
1/ See also Mica (Natural), Scrap and Flake.
2/ Less than 1/2 unit.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions.
5/ Exports and domestic consumption.

Prepared by Lawrence L. Davis, telephone number (202) 634-1206.

7. Government Stockpile: In addition to the quantities shown below, the stockpile contains the following nonstockpile-grade material: 207,000 pounds, muscovite block, stained or better; 640 pounds, muscovite film, 1st and 2nd qualities; 114,000 pounds, phlogopite block; and 181,000 pounds of muscovite block, stained or lower.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Block: Muscovite	6,200	5,008	-	-
Phlogopite	210	17	-	-
Film: Muscovite	90	1,176	1,032	3
Splittings: Muscovite	12,630	14,546	154	108
Phlogopite	930	1,519	-	-

8. Events, Trends, and Issues: Demand for sheet mica was unchanged in 1987. After a long downward trend beginning in the 1950's, demand has remained relatively constant since 1982 indicating that the negative impacts of substitute materials and electronics miniaturization have lessened. Shipments from Government stockpile excesses were resumed but were only a minor source of supply. Imports remained the primary source of sheet mica. There were no environmental problems associated with the manufacture of mica products.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States	2/	2/	Very Small	Small
Brazil	200	200	Moderate	Large
India	5/15,200	15,200	Very Large	Very large
Madagascar	300	300	Moderate	Large
Other Market Economy Countries	200	200	Small	Moderate
Centrally Planned Economies	400	400	Moderate	Large
World Total	16,300	16,300	Large	Large

10. World Resources: There has been no formal evaluation of world resources of sheet mica because of the sporadic occurrence of this material. Large deposits of mica-bearing rock are known to exist in countries such as India, Brazil, and Madagascar. Limited resources of sheet mica are available in the United States. These domestic resources are uneconomic because of the high cost of hand labor required to mine and process the sheet mica.

11. Substitutes: Plastics, fiberglass, and ceramics for many electrical and electronic uses; mica paper, made from scrap mica, for electrical uses.

MOLYBDENUM

(Data in thousand pounds of molybdenum content, unless noted)

1. **Domestic Production and Use**: In 1987, molybdenum valued at about $211 million (based on average oxide price) was produced by seven firms. Two mines in Colorado and Idaho mined molybdenum ore. Seven mines in Arizona, Montana, and Utah recovered molybdenum as a byproduct or coproduct from copper. Two plants converted molybdenite (MoS_2) concentrate to molybdic oxide (MoO_3) from which intermediate products such as ferromolybdenum, metal powder, and various chemicals were produced. Iron and steel producers accounted for about 60% of the molybdenum consumed. Major end-use applications were as follows: machinery, 30%; oil and gas industry, 15%; transportation, 15%; chemicals, 15%; electrical, 15%; and other, 10%.

2. **Salient Statistics--United States**:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, mine	33,593	103,664	108,409	93,976	65,000
Imports for consumption	8,924	8,434	5,065	6,602	15,000
Exports, all primary forms	52,385	75,891	76,023	58,905	50,000
Consumption: Reported	27,225	34,792	33,451	31,898	28,000
Consumption: Apparent	39,000	41,000	45,429	42,467	31,000
Price, average value, dollars per pound 1/	3.64	3.56	3.33	2.92	3.25
Stocks: Mine and mill concentrate, yearend	11,637	12,450	9,322	8,715	9,000
Stocks: Other, producer and consumer, yearend	32,026	26,048	25,455	25,268	24,000
Employment, mine and mill, molybdenum production	2,500	3,600	2,200	600	500
Net import reliance 2/ as a percent of apparent consumption	3/ 7	E	E	E	E

3. **Recycling**: Some secondary molybdenum in the form of metal or superalloys was recovered, but the amount was small. An indeterminate quantity of molybdenum was reclaimed from spent catalysts. Although some molybdenum was recycled as a minor constituent of scrap alloy steels and iron, the use of such scrap did not generally depend on its molybdenum content.

4. **Import Sources (1983-86)**: Chile, 31%; Canada, 21%; Federal Republic of Germany, 12%; Mexico, 11%; other 25%.

5. **Tariff**: In 1987, there was no tariff for molybdenum concentrate imported from Chile, Mexico, Niger, and Peru.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Concentrate, molybdenum content	601.33	9.0¢/lb.	35¢/lb.
Ferromolybdenum, molybdenum content	606.31	4.5% ad val.	31.5% ad val.

6. **Depletion Allowance**: 22% (Domestic), 14% (Foreign).

7. **Government Stockpile**: None.

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e/ Estimated. E Net exports.

1/ Major producer price per pound of molybdenum contained in technical-grade molybdic oxide.

2/ Defined as imports - exports + adjustments for Government and industry stock changes.

3/ Unusually large decreases in domestic stocks resulted in a positive net import reliance as a percent of apparent consumption.

4/ See page 184 for definitions.

Prepared by John W. Blossom, telephone number (202) 634-1021.

8. **Events, Trends, and Issues:** The 1987 molybdenum market reflected continuing over-supply conditions. The surplus conditions restrained the recovery of the market.

U.S. mine output of molybdenum in 1987 decreased 31% when compared with that of 1986. Compared with that of 1986, apparent consumption decreased about 27%, and exports of molybdenum decreased by about 15%. U.S. producer inventories remained about the same compared with those of 1986.

It is estimated that in 1988, domestic mine production of molybdenum will be 70 million pounds and U.S. apparent consumption will be 35 million pounds.

As a result of a soft market, the domestic price for technical-grade molybdic oxide averaged $3.10 per pound of contained molybdenum during 1987. Mine capacity utilization was 35%.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States	93,976	65,000	6,000,000	11,800,000
Canada (shipments)	28,440	25,000	1,000,000	2,000,000
Chile	35,971	40,000	2,500,000	5,400,000
Mexico	7,720	8,000	200,000	500,000
Peru	7,681	8,000	300,000	500,000
Other Market Economy Countries	644	1,000	-	600,000
Centrally Planned Economies	31,600	32,000	2,200,000	5,200,000
World Total	206,032	179,000	12,200,000	26,000,000

10. **World Resources:** Identified resources amount to about 19 billion pounds of molybdenum in the United States and about 46 billion pounds in the world. Molybdenum occurs both as the principal metal sulfide in large low-grade porphyry molybdenum deposits and as a subsidiary metal sulfide in low-grade porphyry copper deposits. Resources of molybdenum are adequate to supply world needs for the foreseeable future.

11. **Substitutes:** There is little substitution for molybdenum in its major applications as an alloying element in steels, cast irons, and nonferrous metals. In fact, because of its availability and versatility, industry has sought to develop new materials which benefit from the alloying properties of molybdenum. Potential substitutes for molybdenum include chromium, vanadium, columbium, and boron in alloy steels; tungsten in tool steels; graphite, tungsten, and tantalum for refractory materials in high temperature electric furnaces; and chrome-orange, cadmium-red, and organic-orange pigments for molybdenum orange.

NICKEL

(Data in short tons of nickel content, unless noted)

1. **Domestic Production and Use**: One copper refinery produced byproduct nickel materials. Secondary nickel was recovered from stainless and alloy steel scrap, nickel-based alloy scrap, and copper smelter residues. One firm converted particulate wastes from stainless steel plants and spent catalysts into nickel-bearing pigs for making stainless steel. On a monthly or annual basis, 316 companies reported nickel consumption. Approximately 39% of the primary nickel consumed went into stainless and alloy steel production, 28% into nonferrous alloys, and 22% into electroplating. Ultimate end uses were: transportation, 24%; chemical industry, 15%; electrical equipment, 9%; construction, 9%; fabricated metal products, 8%; petroleum, 8%; household appliances, 7%; machinery, 7%; and other, 13%.

2. **Salient Statistics--United States**:

	1983	1984	1985	1986	1987 e/
Production: Mine	-	14,540	6,127	1,175	-
Plant, refined metal:					
From domestic ore 1/	W	9,604	5,214	1,651	W
From foreign matte	33,400	35,329	31,168	-	-
Secondary	50,000	55,167	53,645	43,726	55,000
Imports for consumption	152,333	176,715	157,690	129,094	150,000
Exports, primary forms	23,359	31,638	21,745	2,812	1,000
Consumption: Reported, primary	127,845	136,861	119,907	107,062	140,000
Reported, secondary	42,034	49,649	42,295	31,826	40,000
Apparent 2/	201,000	210,600	216,500	181,300	210,000
Price (cathode), dollars per pound, New York dealer	2.20	2.22	2.26	1.86	2.15
Stocks: Consumer, yearend	20,448	20,934	19,106	16,557	9,857
Producer, yearend 3/	38,500	37,300	17,400	10,300	11,000
Employment, yearend: Mine e/	160	130	130	-	-
Smelter e/	230	170	170	-	-
Refinery e/	420	420	-	-	-
Net import reliance 4/ as a percent of apparent consumption	5/75	69	73	75	5/74

3. **Recycling**: About 55,000 tons of nickel was recovered from purchased scrap in 1987. This represented about 26% of apparent consumption for the year.

4. **Import Sources (1983-86)**: Canada, 43%; Australia, 13%; Norway, 12%; Botswana, 8%; other, 24%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN)	Non-MFN
		1/1/87	1/1/87
Nickel ore and concentrates	601.36	Free	Free
Nickel oxide	419.72	Free	Free
Ferronickel	606.20	Free	3¢/lb.
Unwrought nickel	620.03	Free	3¢/lb.
Waste and scrap	620.04	Free	3¢/lb.
Nickel flakes	620.30	Free	14¢/lb.
Nickel powders	620.32	Free	3¢/lb.
Other, over 10% nickel	603.60	Free	Free

6. **Depletion Allowance**: 22% (Domestic), 14% (Foreign).

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Includes byproduct nickel from primary copper operations.
2/ Defined as primary nickel produced in plants from domestic ores + scrap recovery + net import reliance.
3/ Stocks of producers, agents, and dealers held only in the United States.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ Nickel production from domestic ore assumed to be zero for this calculation.
6/ See page 184 for definitions.
7/ Excludes Other Centrally Planned Economies.

Prepared by William S. Kirk, telephone number (202) 634-1025.

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Nickel	200,000	37,215	-	-

8. Events, Trends, and Issues: Domestic primary nickel consumption increased significantly, primarily because of increased demand for stainless steel. The increase in demand was partly a result of a decrease in imports of finished stainless steel products owing to the relative weakness of the dollar. It is estimated that in 1988, domestic mine production of nickel will be zero, and U.S. apparent consumption will be about 220,000 tons. Prices rose considerably in 1987. Although there was no basic nickel shortage, high demand combined with summer production shutdowns caused a temporary tight supply situation. The producer's summer shutdowns usually coincide with a slowdown in the steel sector, but booming demand for stainless and nickel-bearing specialty steels kept that market active.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 6/	Reserve Base 6/
	1986	1987 e/		
United States	1,175	-	300,000	2,800,000
Australia	77,000	75,000	2,300,000	5.300,000
Botswana	22,000	25,000	450,000	500,000
Brazil	25,400	30,000	900,000	4,700,000
Canada	199,077	220,000	8,000,000	14,800,000
Colombia	24,300	25,000	650,000	700,000
Dominican Republic	24,300	27,000	800,000	1,100,000
Finland	7,200	7,000	40,000	50,000
Greece	19,300	9,000	2,600,000	2,800,000
Indonesia	48,300	48,000	4,300,000	5,800,000
New Caledonia	71,700	71,000	2,000,000	17,000,000
Philippines	15,000	11,000	2,000,000	5,100,000
South Africa, Republic of	27,600	27,000	2,800,000	2,900,000
Zimbabwe	12,100	12,000	200,000	1,900,000
Other Market Economy Countries	462	500	-	8,700,000
Albania	10,700	10,000	200,000	200,000
China	28,100	25,000	800,000	1,000,000
Cuba	36,000	37,000	20,000,000	25,000,000
U.S.S.R.	205,000	205,000	7,300,000	8,100,000
Yugoslavia	5,500	5,500	1,400,000	1,800,000
Other Centrally Planned Economies	3,900	4,000	NA	1,000,000
World Total (may be rounded)	864,114	874,000	7/57,000,000	111,000,000

10. World Resources: Identified world resources in deposits averaging approximately 1% nickel or greater contain 143 million tons of nickel. About 80% of the nickel is in laterites and 20% is in sulfide deposits. World resources of lower grade nickel deposits are very large. In addition, there are extensive deepsea resources of nickel in manganese crusts and nodules covering large areas of ocean floor, particularly in the Pacific Ocean.

11. Substitutes: With few exceptions, substitutes for nickel would result in increased cost or some sacrifice in the economy or performance of the product. Present and potential nickel substitutes include aluminum, coated steels, and plastics in the construction and transportation industries; nickel-free specialty steels in the power generating, petrochemical, and petroleum industries; titanium and plastics in severe corrosive applications; and platinum, cobalt, and copper in catalytic uses.

NITROGEN (FIXED)--AMMONIA

(Data in thousand short tons of nitrogen, unless noted)

1. **Domestic Production and Use:** The total f.o.b. value of ammonia produced in the United States in 1987 was estimated to be $1.3 billion. Ammonia was produced by 54 plants owned by 43 firms, primarily by the steam reformation of natural gas. Ammonia manufacture was totally dependent on relatively expensive fossil fuels. Approximately 80% of the ammonia produced was used as fertilizers that include anhydrous ammonia, urea, ammonium phosphates, ammonium nitrate, and other nitrogen compounds. Ammonia also was used to produce plastics, fibers, and resins, 10%; explosives, 4%; and numerous other chemicals, 6%.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production	11,297	13,368	13,238	11,499	12,000
Imports for consumption	2,169	2,699	2,306	2,048	2,000
Exports	298	438	1,010	531	1,000
Consumption, apparent	13,719	15,346	14,439	13,305	12,911
Stocks, producer, yearend	1,422	1,705	1,800	1,511	1,600
Price, dollars per short ton, yearend, quoted f.o.b. gulf coast 1/	175	147	108	75	90
Employment, plant	3,000	3,200	3,000	2,800	2,500
Net import reliance 2/ as a percent of apparent consumption	18	13	8	14	7

3. **Recycling:** None.

4. **Import Sources (1983-86):** Canada, 35%; U.S.S.R., 28%; Trinidad & Tobago, 20%; Mexico, 10%; other, 7%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ammonia, fertilizer	480.6540	Free	Free
Ammonia, chemical	417.2200	2.8% ad val.	28% ad val.

6. **Depletion Allowance:** Not applicable.

7. **Government Stockpile:** None.

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e/ Estimated.
1/ Source: Green Markets Fertilizer Intelligence Weekly, a McGraw-Hill publication.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.

Prepared by Charles L. Davis, telephone number (202) 634-1190.

8. **Events, Trends, and Issues:** The ammonia industry operated at about 80% capacity, producing about the same amount as in 1986. The employment level was slightly reduced because of some plant closings. Ammonia demand remained about the same as that of 1986 because of acreage reduction programs. The overall export demand increased, particularly in Belgium, Mexico, Norway, the Republic of South Africa, Spain, and Taiwan. Ammonia was produced in 22 States. The selling price averaged about $90 per ton f.o.b. gulf coast, slightly higher than the average $84 per ton f.o.b. gulf coast in 1986. Since the profit margin was not much more than the breakeven point, there was little or no reinvestment in plant improvement.

It was estimated that in 1988 domestic production of ammonia in terms of nitrogen content will be 12 million tons and U.S. apparent consumption will be 13 million tons.

9. **World Mine Production, Reserves, and Reserve Base:**

	Plant Production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States	11,499	12,000		
Canada	3,900	3,700		
France	2,200	2,200	Available atmospheric nitrogen and sources of natural gas for the production of ammonia are considered adequate for all countries listed.	
Germany, Federal Republic of	1,800	1,800		
India	5,300	5,500		
Italy	1,300	1,300		
Japan	1,700	1,700		
Mexico	2,100	2,000		
Netherlands	2,280	2,300		
United Kingdom	1,800	1,800		
Other Market Economy Countries	16,360	16,400		
Centrally Planned Economies	45,707	46,000		
World Total	95,946	96,700		

10. **World Resources:** The availability of nitrogen from the atmosphere for fixed nitrogen production is unlimited. Hydrogen required for ammonia production is most commonly obtained from natural gas and by gasification of solid and liquid fuels. Natural gas is widely used to manufacture ammonia because of the favorable costs compared with the cost of solid or liquid fuels. Natural nitrogen compounds occur in the Atacama Desert of Chile, where an estimated 2.5 billion tons of ore are above a cutoff of 7% sodium nitrate. The balance of the Atacama Desert resource may be as large as 25 billion tons.

11. **Substitutes:** Nitrogen is an essential fertilizer element which has no substitute. There are no lower cost substitutes for fixed nitrogen explosives and blasting agents in convential uses. Specific substitutes are available for plastics, fibers, and synthetics but with changes in product characteristics.

PEAT

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: The estimated value of U.S. production of peat for agricultural use in 1987 was about $21 million. Domestic production and imports increased slightly, and apparent demand decreased slightly compared with that of 1986. There were 92 active operations in 21 States. The five principal peat producing States, Florida, Michigan, Illinois, Indiana, and Colorado, accounted for about 80% of U.S. production.

   The demand for packaged peat was unchanged. In 1987, packaged peat totaled about 54% of U.S. peat sales and was used primarily for soil improvement and potting soil. Peat sold in bulk totaled 46% of U.S. peat sales and was used primarily for soil improvement, potting soils, nurseries, and golf courses.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production	704	800	839	886	900
Commercial sales	725	814	882	1,012	933
Imports for consumption	419	485	477	553	560
Exports			None		
Consumption, apparent	1,042	1,146	1,255	1,537	1,500
Price, average value, dollars per ton	25.73	24.47	24.81	23.27	23.00
Stocks, producer, yearend	438	577	638	540	500
Employment, mine and plant	670	700	725	730	730
Net import reliance 1/ as a percent of apparent consumption	32	30	33	42	40

3. Recycling: None.

4. Import Sources (1983-86): Canada, more than 99%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Peat moss, poultry-grade	192.5000	Free	50¢ per long ton
Peat moss, fertilizer-grade	480.8060	Free	Free

6. Depletion Allowance: 5% (Domestic).

7. Government Stockpile: None.

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e/ Estimated.

[1] Defined as imports - exports + adjustments for Government and industry stock changes.

[2] See page 184 for definitions.

Prepared by Charles L. Davis, telephone number (202) 634-1190.

8. Events, Trends, and Issues: Environmental issues continued to incumber peat operations in several States, causing permitting and operational constraints. Opposition to peat production varied from exerting pressure on authorities to stop peat production completely to having operational and permitting constraints placed on peat production. Actions were initiated to have peat bogs classified as wetlands, which would place the bog under U.S. Environmental Protection Agency regulations. Many peat producers could not afford to mitigate these environmental constraints and were forced to close, causing unemployment and erosion of the local tax base.

   Groundbreaking ceremonies were held for a peat-fired 22,800-kilowatt electric powerplant at Deblois, ME. The project was developed by a Bangor, ME, based company. The powerplant's electrical output was expected to serve about 15,000 residential and commercial customers, who would purchase the plant's electrical production. The plant was scheduled for completion by the end of 1988.

   It is estimated that in 1988, domestic production of peat will be 920,000 tons and U.S. apparent consumption will be 1.6 million tons.

9. World Mine Production, Reserves, Reserve Base:

	Production		Reserves 2/	Reserve Base 2/
	1986	1987 e/		
United States	886	900	16,000	7,000,000
Canada	647	650	24,000	336,000,000
Finland	3,520	3,550	70,000	7,000,000
Germany, Federal Republic of	2,140	2,150	46,000	500,000
Ireland	3,405	3,400	171,000	900,000
Other Market Economy Countries	944	1,000	19,000	15,000,000
U.S.S.R.	260,000	260,000	5,320,000	160,000,000
Other Centrally Planned Economies	297	300	6,000	1,600,000
World Total (may be rounded)	271,839	272,000	5,670,000	528,000,000

10. World Resources: World resources of peat are estimated at 2.1 trillion tons, of which the U.S.S.R. has about 850 billion tons and Canada about 560 billion tons. Domestic deposits of peat occur in all 50 States, with estimated resources of about 340 billion tons, or about 16% of the world total.

11. Substitutes: Straw, tree bark, and other fibrous plant materials can be used as a mulch, and, in some instances, substituted for peat as a soil additive in agriculture. The superior water-holding capacity of peat limits this substitution.

PERLITE

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: The estimated value, f.o.b. mine, of processed perlite produced in 1987 was $16.3 million. Crude ore production came from 12 mines operated by 11 companies in 6 Western States. The leading five companies supplied 93% of production. New Mexico, with 85% of the U.S. crude ore mined, continued to be the major producing State. Processed ore was expanded at 62 plants in 32 States. The principal end uses were building construction products; 70%, and filter aid, 12%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production 1/	474	498	518	507	514
Imports for consumption	36	46	52	60	60
Exports e/	17	20	20	30	30
Consumption, apparent	493	524	550	537	544
Price, average value, dollars per ton, f.o.b. mine	33.05	33.41	33.85	30.86	31.71
Stocks, producer, yearend	Not available				
Employment, mine and mill	150	150	150	150	150
Net import reliance 2/ as a percent of apparent consumption	4	5	6	6	6

3. Recycling: None.

4. Import Sources (1983-86): Greece, 100%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude mineral substances, not specifically provided for	523.81	Free	Free

6. Depletion Allowance: 10% (Domestic), 10% (Foreign).

7. Government Stockpile: None.

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e/ Estimated.

1/ Processed perlite sold and used by producers.

2/ Defined as imports - exports + adjustments for Government and industry stock changes; changes in stocks not available and assumed to be zero for apparent consumption and net import reliance calculations.

3/ See page 184 for definitions.

Prepared by Arthur C. Meisinger, telephone number (202) 634-1185.

8. Events, Trends, and Issues: Although imports of perlite from Greece have increased, the supply of perlite from domestic reserves is expected to adequately meet requirements. It is estimated that in 1988 domestic production of processed perlite will be 520,000 tons and apparent consumption will be 550,000 tons.

Perlite mining has the normal problems of disposal of overburden and the ultimate condition of the abandoned pit sites, but overall it results in a relatively small area of disturbed surface. Mining generally occurred in remote areas and environmental problems were not severe.

9. World Processed Perlite Production, Crude Ore Reserves, and Reserve Base:

	Production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States	1/507	1/514	50,000	200,000
Greece	190	190	50,000	300,000
Other Market Economy Countries	276	275	100,000	500,000
Centrally Planned Economies	825	825	500,000	1,000,000
World Total (may be rounded)	1,800	1,800	700,000	2,000,000

10. World Resources: Very little information is available in perlite-producing countries to estimate resources with any reliability.

11. Substitutes: Alternate materials can be substituted for all uses of perlite, if necessary. Long-established competitive commodities include vermiculite, pumice, slag, diatomite, and expanded clay and shale.

PHOSPHATE ROCK

(Data in thousand metric tons, unless noted)

1. **Domestic Production and Use**: Marketable phosphate rock was produced by 16 companies, and the estimated value was $800 million. Nine companies in Florida and one in North Carolina produced 91% of the phosphate rock. The balance, 9%, was produced in Idaho, Montana, Tennessee, and Utah. The principal domestic markets for phosphate rock were fertilizer, 92%; and chemicals manufactured from either elemental phosphorus or purified wet process phosphoric acid, 8%.

2. **Salient Statistics--United States**:

	1983	1984	1985	1986	1987 e/
Production 1/	42,573	49,197	50,835	38,710	40,000
Sold or used by producers	46,839	53,277	46,634	40,580	42,000
Imports for consumption	9	9	34	528	600
Exports	12,010	11,528	9,136	7,848	8,000
Consumption 2/	34,838	41,758	37,532	33,260	34,600
Price, average value, dollars per ton, f.o.b. mine 3/	23.97	23.99	24.31	22.67	20.00
Stocks, producer, yearend	14,500	11,897	15,534	12,658	11,500
Employment, mine and beneficiation plant	7,500	6,500	5,500	4,500	5,700
Net import reliance 4/ as a percent of apparent consumption	Net exporter				

3. **Recycling**: None.

4. **Import Sources (1983-86)**: Togo, 88%; Morocco, 7%; Netherlands Antilles, 4%; other, 1%. The increase in imports reflects demand for high-quality and high-grade phosphate rock for liquid fertilizer production.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Phosphates, crude and apatite	480.4500	Free	Free

6. **Depletion Allowance**: 14% (Domestic), 14% (Foreign).

7. **Government Stockpile**: None.

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e/ Estimated.

1/ Marketable.

2/ Defined as sold or used plus imports minus exports.

3/ Marketable phosphate rock, weighted value, all grades, domestic and exports.

4/ Defined as imports - exports + adjustments for Government and industry stock changes.

5/ Cost less than $35 per metric ton. Cost includes capital, operating expenses, taxes, royalties, and a 15% return on investment, f.o.b. mine.

6/ The criteria for the reserve base were established by a joint Bureau of Mines and U.S. Geological Survey working group. The criteria for classification of phosphate resources are shown in Geological Survey Circular 882, Sedimentary Phosphate Resource Classification System of the U.S. Bureau of Mines and the U.S. Geological Survey.

Prepared by William F. Stowasser, telephone number (202) 634-1190.

8. Events, Trends, and Issues: The demand for phosphate rock in the domestic market was again curtailed by Government acreage reduction programs which reduced consumption of phosphate fertilizer by the agricultural sector. Export demand for phosphate rock, phosphate fertilizers, and cereals did not improve for U.S. producers. Phosphate rock export shipments were maintained by competing at lower prices, phosphate fertilizer exports were marginally profitable, and food and fiber exports were similar in tonnage to those of 1986.

The selling price of 68% bone phosphate of lime phosphate rock from Florida and North Carolina declined from about $23 per ton in 1986 to about $21 per ton in 1987, shrinking or eliminating the profit margin for many producers. The stress of international competition, a factor in international trade in phosphate rock, was expanded to include phosphoric acid and ammonium phosphates as new phosphate fertilizer capacity was brought onstream in several phosphate rock producing countries.

Subsidized farm income was about $30 billion in 1986 and about the same in 1987. The Government subsidies supplied about one-third of a farmer's income.

It is estimated that in 1988, domestic production of phosphate rock will be 40 million tons and U.S. consumption will be 35 million tons.

9. World Production, Reserves, and Reserve Base:

	Production		Reserves 5/	Reserve Base 6/
	1986	1987 e/		
United States	1/38,710	1/40,000	1,300,000	5,200,000
Israel	3,673	3,700	-	190,000
Jordan	6,249	6,500	120,000	510,000
Morocco and Western Sahara	21,178	22,000	7,000,000	22,000,000
Senegal	1,850	1,900	40,000	170,000
South Africa, Republic of	2,920	2,900	2,500,000	2,500,000
Togo	2,314	2,300	40,000	70,000
Tunisia	5,951	6,000	20,000	300,000
Other Market Economy Countries	14,218	15,300	400,000	3,400,000
China	6,700	10,000	210,000	210,000
U.S.S.R.	32,500	32,500	1,300,000	1,300,000
Other Centrally Planned Economies	800	800	325,000	325,000
World Total (may be rounded)	137,063	144,000	13,255,000	36,175,000

10. World Resources: Most of the U.S. and world phosphate rock resources are widely distributed marine phosphorite deposits. Identified and undiscovered resources are estimated to contain billions of tons of contained phosphorus. Identified resources in North and West Africa and in the Middle East are estimated to be several times greater than present reserves. Large phosphate resources have been identified on the continental shelves and on sea mounts in the Atlantic and Pacific Oceans. Phosphate rock contains fluorine as an integral part of the mineral apatite. Uranium and the rare earths are associated with the apatite mineral of phosphate deposits, and vanadium with the organic fraction of marine phosphorites. Uranium is more abundant in the marine phosphorites, while the rare earths are more abundant in igneous apatites.

11. Substitutes: There are no substitutes for phosphorus in agriculture.

PLATINUM-GROUP METALS

(Platinum, palladium, iridium, osmium, rhodium, ruthenium)
(Data in thousand troy ounces, unless noted)

1. Domestic Production and Use: Refined platinum-group metals (PGM) were recovered as byproducts of copper refining by two companies in Utah and Texas. In the first quarter of 1987, a new PGM mine came on-stream in Montana and began shipping concentrates to Belgium for toll processing. The recovered PGM were to be returned to the United States. Secondary metal was refined by about 17 firms, mostly on the east and west coasts. PGM were sold by at least 90 processors and retailers, largely in the Northeast, and were distributed among using industries as follows: automotive, 42%; electrical and electronic, 20%; dental and medical, 20%; chemical, 5%; other, 13%. The automotive, chemical, and petroleum refining industries used PGM mainly as catalysts. The other industries used PGM in a variety of ways that took advantage of their chemical inertness and refractory properties.

2. Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Mine	6	15	W	W	W
Primary refined	9	24	7	34	30
Secondary:					
Nontoll-refined	303	340	259	231	240
Toll-refined	995	1,157	1,038	903	1,100
Imports for consumption:					
Refined	2,790	3,928	3,438	3,727	3,050
Total	3,218	4,474	3,990	4,477	3,600
Exports:					
Refined	446	599	526	382	400
Total	1,229	1,162	889	751	660
Consumption: Reported, sales to industry	1,914	2,200	2,271	2,250	1,900
Apparent 1/	2,813	3,299	3,358	2,950	2,040
Price, dealer, average, dollars per ounce:					
Platinum	424	357	291	461	560
Palladium	136	148	107	116	130
Stocks, industry, yearend:	943	1,319	1,129	1,754	2,600
Shipments from Govt. stockpile excesses 2/	(4)	(9)	(2)	-	-
Employment, refinery e/	400	400	400	400	400
Net import reliance 3/ as a percent of apparent consumption	89	89	92	92	88

3. Recycling: About 240,000 ounces of PGM were refined from scrap on a nontoll basis. The quantity of toll-refined secondary was much larger, amounting to about 1.1 million ounces. After the introduction of automotive emission control catalysts on domestic vehicles in 1974, PGM was being recovered in significant quantities from the catalysts. One company in Alabama concentrated PGM from scrap automotive catalysts, and two companies, one in New Jersey and the other in Illinois, exported decanned catalyst for processing.

4. Import Sources (1983-86): Republic of South Africa, 42%; United Kingdom, 18%; U.S.S.R., 10%; other, 30%.

5. Tariff:	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore	601.39	Free	Free
Metals	605.02, 605.07	Free	Free
Alloys	605.03, 605.08	8.2% ad val.	65%.0% ad val.
Scrap	605.70	Free	Free

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Domestic mine production plus nontoll secondary production plus net import reliance (see footnote 3). Mine production for 1985-87 assumed to be zero for the calculation.
2/ Data in parentheses denote stockpile acquisitions.
3/ Defined as refined imports - refined exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions.
5/ Excludes U.S. production.

Prepared by J. Roger Loebenstein, telephone number (202) 634-1058.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile: No PGM were purchased in 1987. The stockpile purchase policy and specifications for PGM were reviewed by a panel of industry and Government experts in 1987. The panel recommended that the Government purchase rhodium and ruthenium, at least 99.95% pure, for the National Defense Stockpile. Both metals are important for the production of chemical intermediates.

Stockpile Status-9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months	Purchases 9 Months
Platinum	1,310	440	-	-	-
Palladium	3,000	1,262	-	-	-
Iridium	98	30	-	-	-

In addition to quantities shown above, the stockpile contains 13,043 ounces of nonstockpile-grade platinum and 2,214 ounces of nonstockpile grade palladium.

8. Events, Trends, and Issues: Consumption of PGM declined in 1987. Consumption in all end uses was lower than in 1986, with the largest end use remaining automotive emission control catalysts. It is estimated that in 1988, U.S. apparent consumption of PGM will be 2 million ounces.

On January 7, 1987, pursuant to Section 303(a)(2) of the Comprehensive Anti-Apartheid Act of 1986, the PGM were certified by the Department of State as strategic minerals essential for the economy or defense of the United States that are unavailable in adequate quantities from reliable and secure suppliers.

Mining of platinum and palladium in the Stillwater Complex, MT, began in the first quarter of 1987. Ore was mined at the rate of 500 short tons per day; concentrates were shipped to Belgium to be smelted and refined on a toll basis.

Five companies in the Republic of South Africa not heretofore engaged in PGM mining were exploring and developing deposits. In addition, two of the existing three South African PGM producers planned to expand existing mining capacity. Production of PGM was spurred by relatively high platinum prices in 1986 and 1987 and the anticipation of high future demand for PGM from the West European automobile industry for emission control.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production 1986	Mine Production 1987 e/	Reserves 4/	Reserve Base 4/
United States	W	W	8,000	25,000
Canada	281	300	8,000	9,000
South Africa, Republic of	3,600	3,700	1,600,000	1,900,000
Other Market Economy Countries	103	103	1,000	1,000
U.S.S.R.	3,850	3,850	190,000	200,000
World Total (rounded)	5/7,800	5/8,000	1,810,000	2,140,000

Bureau of Mines estimates for reserves of PGM, shown above, have been raised since they were last published, in 1985, to reflect recent information on the PGM deposit in Montana, and the greater depths from which PGM are being mined in the Republic of South Africa.

10. World Resources: World resources of PGM are estimated to be 3.3 billion ounces. U.S. resources are estimated at 300 million ounces.

11. Substitutes: The feasibility of substituting other materials for PGM is greatest for electronic applications and least for catalytic applications. Tin-lead alloys can substitute for palladium-silver alloys used in multilayer capacitors. In dental crowns, gold, silver, and sometimes titanium can substitute for palladium alloys. Research continues into the use of base metals clad or plated with PGM, and into other ways of minimizing the quantities of PGM used in various industrial applications.

POTASH

(Data in thousand metric tons of K_2O equivalent, unless noted)

1. Domestic Production and Use: The value of U.S. production of marketable potash, f.o.b. mine, in 1987 was about $165 million. Potash production was centered in southeastern New Mexico, where five companies, operating five mines, by conventional mining of bedded deposits, produced 87% of the U.S. total. In Utah, one company brought potash to the surface by solution mining a deep, bedded, folded deposit. The potash was recovered from the brine using solar evaporation and flotation. Another company collected subsurface brines for solar evaporation and flotation. In California, one company recovered potash and coproduct boron compounds and salt cake from subsurface brines using various crystallization techniques. About 95% of U.S. potash sales was used directly in the fertilizer industry and about 5% was used in the chemical industry. Most potash was produced as potassium chloride (muriate of potash). Potassium sulfate (sulfate of potash) and potassium magnesium sulfate, produced for special crops and soils, comprised about 20% of the potash production. Potash was distributed by train, truck, and barge to warehouses, wholesalers, and retailers; some potash was sold from barges used as temporary warehouses. Retailers sold both potash and potash blended with other fertilizers in dry or liquid forms for distribution over the fields in both spring and fall.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, marketable	1,429	1,564	1,296	1,202	1,360
Imports for consumption	4,440	4,829	4,593	4,212	3,900
Exports	300	446	513	547	400
Consumption, apparent	5,653	6,022	5,346	4,843	4,890
Price, dollars per metric ton of K_2O, average, muriate, f.o.b. mine 1/	100	109	96	82	75
Stocks, producer, yearend	2/391	3/312	4/336	5/378	348
Employment: Mine	1,220	1,110	1,050	975	930
Mill	930	875	825	750	670
Net import reliance 6/ as a percent of apparent consumption	75	74	76	75	72

3. Recycling: None.

4. Import Sources (1983-86): Canada, 91%; Israel, 6%; German Democratic Republic, 1%; U.S.S.R., 1%; other, 1%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Potassium chloride	480.50	Free	Free
Potassium sulfate	480.55	Free	Free
Potassic fertilizers and fertilizer materials	480.75	Free	Free

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated.
1/ Average prices based on actual sales, excludes soluble and chemical muriates.
2/ Inventory adjustment of minus 46,000 tons.
3/ Inventory adjustment of minus 4,000 tons.
4/ Inventory adjustment of minus 6,000 tons.
5/ Inventory adjustment of minus 12,900 tons.
6/ Defined as imports - exports + adjustments for Government and industry stock changes.
7/ U.S. Department of Agriculture. Agricultural Outlook. AO-134, Sept. 1987, pp. 22-27.
8/ See page 184 for definitions.
9/ Total reserve base in the Dead Sea is equally divided between Israel and Jordan.

Prepared by James P. Searls, telephone number (202) 634-1190.

8. Events, Trends, and Issues: Compared with that of 1986, demand for potash in the United States was essentially unchanged and production increased about 13%. Farm land values tended to level out and farm debt declined.7/ Large stocks of grains from 1986 discouraged the farmer from planting large acreages or fertilizing heavily in 1987.

In February, two potash producers in New Mexico filed antidumping petitions against the Canadian potash producers. The U.S. International Trade Commission found a likelihood of damage and the International Trade Administration of the U.S. Department of Commerce set preliminary dumping margins. The Canadian potash producers raised their prices to attempt to cover the cost of the dumping margins and generally raised the effective price of potash, to the benefit of U.S. producers.

The low price of potash in the spring of 1987 brought about the sale in late summer of the Canadian potash company that was developing the potash resource in Michigan. In addition, one of the New Mexico producers filed for protection from creditors under Chapter 11 of the Federal Bankruptcy Code.

It is estimated that in 1988, domestic mine production of potash will be 1.4 million tons and U.S. apparent consumption will be 5.6 million tons.

9. World Mine Production, Reserves, and Reserve Base:

	Production		Reserves 8/	Reserve Base 8/
	1986	1987 e/		
United States	1,202	1,360	60,000	320,000
Canada (sales)	6,969	6,800	1,300,000	9,700,000
France	1,617	1,600	40,000	50,000
Germany, Federal Republic of	2,165	2,100	500,000	600,000
Israel	1,255	1,260	300,000	9/600,000
Italy	158	180	30,000	40,000
Jordan	660	700	300,000	9/600,000
Spain	702	750	40,000	50,000
United Kingdom	400	430	25,000	30,000
Other Market Economy Countries	30	30	350,000	450,000
Developing Countries	-	-	30,000	120,000
German Democratic Republic	3,450	3,450	800,000	1,000,000
U.S.S.R.	9,600	9,900	3,000,000	3,800,000
Other Centrally Planned Economies	40	100	200,000	220,000
World Total (may be rounded)	28,248	28,660	7,000,000	18,000,000

10. World Resources: Estimated domestic potash resources total about 6 billion tons. Most of this lies between 6,000 and 10,000 feet deep, in a 1,200-square-mile area of Montana/North Dakota as an extension of the Williston Basin deposits in Saskatchewan. The Paradox Basin in Utah contains approximately 2 billion tons, mostly at depths of more than 4,000 feet. An unknown quantity of potash resources lies about 7,000 feet under central Michigan. Estimated world resources total about 250 billion tons. The potash deposits in the U.S.S.R. account for most of the centrally planned economy countries' resources. Very large resources, about 10 billion tons and mostly carnallite, occur in Thailand.

11. Substitutes: There are no substitutes for potash as an essential plant nutrient.

PUMICE AND PUMICITE

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use:** The estimated value of pumice and pumicite sold or used in 1987 was $5.8 million. Domestic output came from 18 producers in 7 States. The principal producing States were California, Idaho, New Mexico, and Oregon; their combined production accounted for about 97% of the national total. California led all producing States with six active operations. The major uses of pumice and pumicite were in concrete aggregate and building block, about 90% of apparent consumption.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, mine 1/	449	502	508	554	563
Imports for consumption	184	293	242	385	350
Exports e/	1	1	1	1	3
Consumption, apparent	632	794	749	938	910
Price, average value, dollars per ton, f.o.b. mine or mill	9.99	9.82	8.96	10.39	10.30
Stocks, yearend		Not available			
Employment, mine and mill	60	60	60	50	50
Net import reliance 2/ as a percent of apparent consumption	29	37	32	41	38

3. **Recycling:** None.

4. **Import Sources (1983-86):** Greece, 96%, other, 4%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Used in the manufacture of masonry products such as building blocks, bricks, tiles, and similar forms	519.05	Free	Free
Crude or crushed:			
Valued not over $15 per ton	519.11	0.01¢/lb	0.1¢/lb
Valued over $15 per ton	519.14	0.035¢/lb	0.25¢/lb
In grains or ground, pulverized or refined	519.31	0.13¢/lb	0.75¢/lb
Millstones, abrasive wheels, and abrasive articles, n.s.p.f.	519.93	4.7% ad val.	35% ad val.
Articles, n.s.p.f.	523.61	2.8% ad val.	35% ad val.

6. **Depletion Allowance:** 5% (Domestic), 5% (Foreign).

7. **Government Stockpile:** None.

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e/ Estimated. NA Not available. n.s.p.f. Not specifically provided for.
1/ Quantity sold and used by producers.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.
4/ Excludes Centrally Planned Economies.

Prepared by Arthur C. Meisinger, telephone number (202) 634-1185.

8. Events, Trends, and Issues: It is estimated that in 1988 domestic mine production of pumice and pumicite will be 550,000 tons and U.S. apparent consumption will be 950,000 tons.

   Changing geographic demand patterns coupled with increasing transportation costs and lack of detailed reserve information could create problems for selecting new production locations.

   All domestic mining of pumice in 1987 was by open pit methods and generally occurred in relatively remote areas where land use conflicts were not severe. Although the generation and disposal of reject fines in mining and milling resulted in a dust problem at some operations, the environmental impact was restricted to a small geographical area.

9. World Mine Production, Reserves, and Reserve Base:

	Production e/		Reserves 3/	Reserve Base 3/
	1986	1987		
United States	554	563	Large	Large
France	550	550	NA	NA
Germany, Federal Republic of	350	350	NA	NA
Greece	1,740	1,750	NA	NA
Italy	5,770	5,800	NA	NA
Other Market Economy Countries	2,550	2,600	NA	NA
Centrally Planned Economies	NA	NA	NA	NA
World Total (rounded)	4/11,500	4/11,600	NA	NA

10. World Resources: The domestic identified resources of pumice and pumicite in the West are estimated to be at least 25 million tons. The estimated resources in the Western and Great Plains States are 250 million to 450 million tons.

11. Substitutes: Transportation cost determines the maximum distance that pumice and pumicite can be shipped and remain competitive with alternate materials. Alternate competitive materials that can be substituted for pumice and pumicite for several end uses include expanded shale and clay, diatomite, and crushed aggregates.

QUARTZ CRYSTAL, INDUSTRIAL

(Data in thousand pounds, unless noted)

1. Domestic Production and Use: There was no reported U.S. production of natural quartz suitable for direct electronic or optical applications. The two lascas1/ mines in Arkansas were idle and supplied feed material from stocks to cultured quartz crystal growers. Six companies grew cultured quartz using lascas as feed material. Quartz crystal was essential for making piezoelectric filter devices that separate desired from undesired portions of the frequency spectrum and oscillators that provided single frequency signal sources. Filters and oscillators were used for a wide variety of communications and instrumentation purposes.

2\.

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Mine e/2/	600	2,500	1,000	1,200	-
Plant, cultured (as-grown)	426	1,027	568	524	700
Imports for consumption:					
Lascas	153	569	173	52	250
Natural electronic 3/	4/	4/	4/	4/	4/
Cultured		Not available			
Exports:					
Lascas	339	e/1,600	e/800	e/-	-
Natural electronic 3/	28	42	60	74	75
Cultured (mostly lumbered) 3/	80	277	185	324	500
Shipments from Govt. stockpile excesses, natural electronic	4	127	84	-	-
Consumption, reported:					
Lascas 5/	677	1,300	522	610	800
Natural electronic	13	7	7	2	2
Cultured 6/	424	468	268	471	600
Consumption, apparent:					
Lascas	673	1,057	307	1,388	540
Natural electronic		Not available			
Cultured		Not available			
Price, average value, dollars per pound:					
Lascas		0.55 to 3.75			
Cultured		15 to 650			
Stocks, industry, yearend:					
Lascas (for cultured crystal only)	746	1,158	876	790	500
Natural electronic (fabricator)	37	23	18	16	14
Cultured (fabricator)	53	134	204	146	150
Employment, mine, processing plant e/	21	75	12	10	10
Net import reliance 7/ as a percent of apparent consumption:					
Lascas	11	E	E	10	100
Natural electronic		Not available			
Cultured		Not available			

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e/ Estimated. E Net Exporter. NA Not available.

1/ Lascas is natural nonelectronic-grade quartz used as feedstock for growing cultured quartz crystal and for production of fused quartz.

2/ Lascas only; specimen and jewelry material excluded.

3/ Quantities calculated from pricing information.

4/ Less than 1/2 unit.

5/ Excluding quartz crystal used by the fused quartz industry.

6/ Reported consumption of cultured includes cultured quartz crystal consumed by growers as well as by manufacturers of intermediate products and finished crystal units.

7/ Defined as imports - exports + adjustments for Government and industry stock changes.

8/ See page 184 for definitions.

Prepared by Joyce A. Ober, telephone number (202) 634-1177.

3. Recycling: None.

4. Import Sources (1983-86): Brazil, 100%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Brazilian Pebble, Crude	521.21	Free	Free

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Quartz crystal	600	1,849	-	-

8. Events, Trends, and Issues: Japan continued as the world leader in the production of cultured quartz crystal because of its lower cost per unit and its prominence as a producer of electronic components in which these crystals are used. The U.S. cultured quartz industry increased production in 1987 after 2 years of decline. Domestic fabricators continued to depend on small quantities of Brazilian natural quartz as seed for growing cultured quartz and for a few direct applications, such as deep well pressure transducers. U.S. quartz growers began using imported lascas from Namibia as a very inexpensive feed material.

9. World Mine Production, Reserves, and Reserve Base:

	Production 1986	Production 1987 e/	Reserves 8/	Reserve Base 8/
United States e/2/	1,200	-	Moderate	Moderate
Brazil	NA	NA	Large	Large
Other Market Economy Countries	NA	NA	NA	NA
Centrally Planned Economies	NA	NA	NA	NA
World Total	NA	NA	NA	NA

10. World Resources: Limited resources of quartz crystal, suitable for direct electronic or optical use, are available throughout the world. World dependence on these resources will continue to decline because of increasing acceptance of cultured quartz crystal as an alternate material; however, this will mean an increased dependence on lascas for growing cultured quartz.

11. Substitutes: Quartz crystal is the best material for frequency-control oscillators. Other materials, such as dipotassium tartrate, are usable only in specific applications as oscillators and frequency filters.

RARE-EARTH METALS 1/

(Data in metric tons of rare-earth oxide (REO) content, unless noted)

1. **Domestic Production and Use:** In 1987, two companies recovered rare-earth ore minerals in the United States. Bastnasite, a rare-earth fluocarbonate mineral, was mined in California as a principal product and accounted for most of domestic rare-earth production. Monazite, a rare-earth phosphate mineral, was mined in Florida by placer methods and was a byproduct of processing heavy minerals sands for titanium and zirconium minerals. Thorium and yttrium were byproducts of the separation of rare earths from monazite. The United States was the world's principal producer and processor of the rare earths and was a major exporter and consumer of rare-earth products. Rare-earth ores and compounds were processed mainly by four companies with plants in Arizona, Texas, Tennessee, California, Colorado, and Pennsylvania. Industrial consumption was estimated as follows: petroleum catalysts, 36%; metallurgical uses (including pyrophoric alloys), 31%; ceramic and glass, 29%; and other uses (electrical, phosphors, permanent magnets, laser crystals, research, and miscellaneous), 4%.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Bastnasite concentrates	17,083	25,311	13,428	11,094	11,000
Monazite concentrates	W	W	W	W	W
Imports for consumption: e/			None		
Monazite	2,215	3,114	3,132	1,628	594
Metals, alloys, oxides, and compounds	1,857	2,926	1,124	1,155	1,279
Exports: e/ Ore and concentrate	2,684	4,304	4,419	3,433	2,668
Ferrocerium and pyrophoric alloys	59	27	23	29	69
Shipments from Govt. stockpile excesses					
Consumption, apparent 2/	19,600	21,400	12,100	11,800	10,300

Price, dollars, yearend 1986: Monazite concentrates, 581.00 per metric ton; bastnasite concentrates, 2.14 per kilogram REO. Prices for processed rare earths, per kilogram: mixed compounds, 1.85 (chloride) to 18.50 (oxalate); high-purity oxides, 20.00 (lanthanum) to 4,900.00 (lutetium); metal, 150.00 (lanthanum) to 14,200.00 (lutetium); mischmetal, 12.35.

	1983	1984	1985	1986	1987 e/
Stocks, producer and processor, yearend	W	W	W	W	W
Employment, mine and mill e/ 3/	266	321	330	283	304
Net import reliance 2/ 4/ as a percent of apparent consumption	12	5/	E	6	E

3. **Recycling:** Insignificant.

4. **Import Sources (1983-86):** Monazite--Australia, 96%; other 4%.

5. **Tariff:**

Tariff:	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrates 6/	601.12 & 601.45	Free	Free
Cerium oxide, compounds	418.42 & 418.44	7.2% ad val.	35.0% ad val.
Rare-earth oxides, except cerium oxide	423.30	3.7% ad val.	25.0% ad val.
Alloys, mischmetal	632.78	32¢/lb	$2/lb
Ferrocerium and other pyrophoric alloys	755.35	22¢/lb + 2.6% ad val.	$2/lb + 25.0% ad val.

6. **Depletion Allowance:** Monazite, 22% on thorium content and 14% on rare-earth content (Domestic), 14% (Foreign). Bastnasite and xenotime, 14% (Domestic and Foreign).

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e/ Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data.
1/ See also Yttrium and Thorium.
2/ Monazite concentrate production assumed to be zero for apparent consumption and net import reliance calculations.
3/ Total employment at a rare-earth mine in California and at heavy minerals sands operations in Florida. The latter mine produced monazite concentrate as a byproduct of mining rutile, ilmenite, and zircon, and employees were not assigned to specific commodities.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ Increase in industry stocks exceeded net imports.
6/ "Concentrates" includes only those made by crushing, flotation, washing, or by other physical or mechanical processes that do not involve substantial chemical change.
7/ See page 184 for definitions.
8/ Comprises only the rare earths derived from bastnasite.

Prepared by James B. Hedrick, telephone number (202) 634-1058.

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
REO in sodium sulfate	-	457	-	-

8. Events, Trends, and Issues: Domestic demand for separated rare earths increased in 1987. However, demand for rare earths used in petroleum fluid cracking catalysts (fcc's) continued to decline as a result of a 1985 Environmental Protection Agency guideline lowering the allowable lead content of gasoline. Rare-earth demand in fcc's is not expected to recover over the long term. Samarium supplies for use in high-strength samarium-cobalt magnets remained in tight supply in 1987 as a result of continued cutbacks in rare-earth concentrate production caused by reduced demand for rare-earth-containing fcc's. However, the availabilty of neodymium for use in high-strength neodymium-iron-boron magnets improved as several companies increased capacity to produce neodymium oxide and neodymium metal. Demand for europium, terbium, gadolinium, and yttrium, for use in phosphors, increased slightly in 1987, while yttrium for ceramics showed stronger growth. High-purity cerium was in higher demand for use in automotive catalytic converter substrates and as catalysts. Supplies of the more abundant rare earths, cerium, lanthanum, praseodymium, and neodymium, and certain less abundant elements, holmium, thulium, ytterbium, and lutetium, were plentiful, but additional separation capacity was planned for certain products to meet expected increased demand. Demand for the individual rare-earths is expected to change at varying rates owing to the wide variety of end uses. Except for rare-earths used in petroleum cracking catalysts, demand for rare earths in most other end uses is expected to increase through 1990. Neodymium is forecast to show the strongest growth during this period as its use in permanent magnets is further commercialized.

As was the situation in 1986, the rare earths were in abundant domestic and world supply, except for samarium, and no critical shortages of any of them were anticipated. The demand pattern continued to shift towards individual compounds and metals and special mixtures, and the capacities to separate and produce these products were increasing to meet the changing demand pattern. Improved knowledge of rare-earth properties continued to bring about new commercial applications. Reserve data, given below, have been revised for Australia, Canada, India, and the United States, as a result of updated information.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production e/		Reserves 7/	Reserve Base 7/
	1986	1987		
United States	8/11,094	8/11,000	5,500,000	6,500,000
Australia	5,820	6,000	345,000	380,000
Brazil	3,300	3,300	20,000	73,000
Canada	-	50	164,000	200,000
India	2,200	2,200	1,800,000	1,900,000
Malaysia	3,300	3,300	30,000	35,000
Thailand	140	140	1,000	1,100
Other Market Economy Countries	110	110	174,000	1,700,000
China	6,750	7,000	36,000,000	36,000,000
Other Centrally Planned Economies	1,500	1,500	450,000	500,000
World Total (rounded)	34,000	35,000	44,000,000	47,000,000

10. World Resources: Some elements of the rare-earth group of metals are relatively abundant in the earth's crust, but minable concentrations are uncommon. Bastnasite is mined extensively in the United States and China. Monazite is recovered largely as a byproduct of processing heavy minerals sands in various parts of the world, primarily Australia and India. The rare earths also occur in many other minerals and are recoverable as byproducts from phosphate rock and from spent uranium leach solutions. Total world undiscovered resources of rare earths are believed to be very large relative to expected demand.

11. Substitutes: Substitutes are available for many applications of rare-earth elements, but generally are less effective. Palladium and ultrastable zeolites can substitutes in petroleum cracking catalysts for rare earth-containing zeolites, but yield a different mix of products.

RHENIUM

(Data in pounds of rhenium content, unless noted)

1. **Domestic Production and Use:** During 1987, rhenium was produced by eight companies. Rhenium was produced from porphyry copper deposits in the southwestern United States and was recovered as a byproduct of roasting molybdenum concentrates. Rhenium-containing products included ammonium perrhenate, perrhenic acid, and metal powder. Platinum-rhenium reforming catalysts continued to be the major end use product and accounted for about 85% of rhenium consumption. These catalysts were used to increase the octane rating in the production of lead-free petroleum products. About 15% of the rhenium was used in the production of thermocouples, heating elements, x-ray tubes and targets, flashbulbs, vacuum tubes, electrical contacts, metallic coatings, and for research and development. The estimated value of rhenium consumed in 1987 was $5 million.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Content 1/	8,100	8,600	10,500	10,900	8,400
Recovered 2/	W	W	W	W	W
Imports for consumption	6,570	6,716	8,268	17,683	18,000
Exports	Negligible				
Consumption: Reported e/	8,800	10,200	13,000	13,000	14,000
Apparent	W	W	W	W	W
Price, average value, dollars per pound:					
Metal powder, 99.99% pure	300	300	300	350	475
Perrhenic acid	250	200	200	200	300
Stocks, yearend, consumer, producer, dealer	W	W	W	W	W
Employment	Small				
Net import reliance 3/ as a percent of apparent consumption	W	W	W	W	W

3. **Recycling:** Small amounts of molybdenum-rhenium and tungsten-rhenium scrap have been processed during the past few years by several companies.

4. **Import Sources (1983-86):** Chile, 71%; Federal Republic of Germany, 19%; other, 10%.

5. **Tariff:** In 1987, there was no tariff for rhenium imported from Chile and Peru.

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Unwrought metal, waste, and scrap 4/	628.90	3.7% ad val.	25% ad val.
Wrought metal	628.95	5.5% ad val.	45% ad val.
Ammonium perrhenate	417.4520	3.1% ad val.	25% ad val.
Perrhenic acid	416.4540	4.2% ad val.	25% ad val.

6. **Depletion Allowance:** 14% (Domestic), 14% (Foreign).

7. **Government Stockpile:** None.

e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Calculated rhenium contained in MoS$_2$ concentrates.
2/ In prior years, this was shown as mine production.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ Duty on waste and scrap suspended indefinitely.
5/ See page 184 for definitions.

Prepared by John W. Blossom, telephone number (202) 634-1021.

8. Events, Trends, and Issues: During 1987, the rhenium metal price increased about 36% from that of 1986. The average price was $475 per pound for rhenium metal and $300 per pound for ammonium perrhenate. Imports of rhenium remained level for 1987. Chile and the Federal Republic of Germany continued to supply the majority of the rhenium imported. The United States relies on imports for most of its supply of rhenium.

It is estimated that in 1988, U.S. consumption of rhenium will be about 14,000 pounds.

Owing to the scarcity and minor output of rhenium, its production and processing pose no known threat to the environment. In areas where it is recovered, pollution control equipment for sulfur dioxide also prevents most of the rhenium from escaping into the atmosphere.

The main problems related to rhenium are: the low recovery of rhenium from porphyry copper ores; uncertain economic return on recovery equipment owing to uncertain future prices and long-term demand; increased use of petroleum reforming catalysts containing no rhenium; and environmental costs imposed on the copper and molybdenum industries which recover rhenium as a byproduct.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 5/	Reserve Base 5/
	1986	1987 e/		
United States	1/10,900	1/8,400	2,000,000	10,000,000
Canada	8,000	8,000	700,000	3,400,000
Chile	9,000	10,000	2,600,000	5,600,000
Peru	1,000	1,000	400,000	1,200,000
U.S.S.R.	12,000	12,000	500,000	1,700,000
Other Countries	1,000	1,000	200,000	800,000
World Total	41,900	40,400	6,400,000	22,700,000

10. World Resources: Most rhenium occurs with molybdenum in porphyry copper deposits. Identified U.S. resources are estimated to be about 10 million pounds, and the identified resources of the rest of the world are approximately 13 million pounds. In the U.S.S.R., rhenium also exists in sedimentary copper deposits.

11. Substitutes: Substitutes for rhenium in platinum-rhenium catalysts are being evaluated continually. Iridium and tin have achieved commercial success in one such application. Other metals being evaluated for catalytic use include gallium, germanium, indium, selenium, silicon, tungsten, and vanadium. The use of these and other metals in bimetallic catalysts may erode rhenium's share of the catalyst market. Materials that can substitute for rhenium in various end uses are: cobalt and tungsten for coatings on copper x-ray targets; rhodium and rhodium-iridium for high temperature thermocouples; tungsten and platinum-ruthenium for coatings on electrical contacts; and tungsten and tantalum for electron emitters.

RUBIDIUM 1/

(Data in pounds of rubidium content, unless noted)

1. **Domestic Production and Use:** One domestic company manufactured rubidium products from lepidolite ore imported from Canada. Small quantities of rubidium, usually in the form of chemical compounds, were used mainly in research and development. Rubidium also was used in electronic and medical applications.

2. **Salient Statistics--United States:**

	1983	1984	1985	1986	1987 e/
Production: Mine	None				
Metal and compounds	W	W	W	W	W
Imports for consumption:					
Ores and raw materials	-	W	-	-	-
Rubidium metal and compounds	Not available				
Exports	Not available				
Consumption, apparent, metals and compounds	Not available				
Price, dollars per pound:					
Metal, 99.5%+, 1-4 pound lots	300	300	300	300	300
Rubidium compounds, range	84-132	90-142	100-145	100-156	103-170
Rubidium oxide	500	500	500	550	550
Stocks, producer, yearend	W	W	W	W	W
Employment, plant e/	25	25	25	25	25
Net import reliance 2/ as a percent of apparent consumption	NA	100	100	100	100

3. **Recycling:** None.

4. **Import Sources (1983-86):** Canada, 100%.

5. **Tariff:**

	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Rubidium	415.40	3.7% ad val.	25.0% ad val.
Rubidium compounds	423.00	3.7% ad val.	25.0% ad val.

6. **Depletion Allowance:** 14% (Domestic), 14% (Foreign).

7. **Government Stockpile:** None.

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ See also Cesium.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.

Prepared by W. Timothy Adams, telephone number (202) 634-1058.

8. Events, Trends, and Issues: In 1987, rubidium and its compounds were largely the subject of laboratory study and were of little commercial significance. No major breakthroughs or developments were anticipated that would change the production or consumption pattern in 1988. Domestic rubidium production is entirely dependent on imported lepidolite ores. Because of the small scale of production of rubidium products, no significant environmental problems have been encountered.

9. World Mine Production, Reserves, and Reserve Base: The Canadian mining operation for lepidolite ore remained closed during 1986. Reserves and the reserve base 3/ for rubidium in North America were estimated at 4.4 million pounds and 5 million pounds, respectively.

10. World Resources:3/ Rubidium forms no known minerals in which it is the predominant metallic constituent, but occurs chiefly as a replacement for potassium, especially in minerals formed late in the crystallization of pegmatites. Meaningful estimates of world rubidium resources have not been made but lepidolite, a potassium lithium mica, may contain up to 1.35% rubidium, and pollucite, a cesium silicate, may contain up to 3.15% rubidium.

11. Substitutes: The properties of cesium and its compounds are so similar to those of rubidium and its compounds that compounds of rubidium and cesium are used interchangeably in many applications. Cesium, germanium, tellurium, selenium, silicon, and several other elements and compounds can substitute for rubidium as photosensitive materials.

RUTILE 1/

(Data in thousand short tons of concentrate, unless noted)

1. **Domestic Production and Use**: Rutile was produced at one mine in Florida in 1987. At two other mines in Florida, rutile was included in a bulk concentrate containing mostly ilmenite and leucoxene. The major coproduct of these titanium minerals is zircon. The value of reported U.S. rutile consumption in 1987, assuming an average price of $400 per ton, was about $138 million. Four firms, one each in Nevada, Ohio, Oregon, and Washington used titanium tetrachloride made from rutile to manufacture titanium metal. Of 17 consuming firms, located mainly in the Eastern United States, 5 companies used 79% of the rutile consumed to make titanium dioxide pigment. Welding rod coatings consumed 2%; miscellaneous applications, which include titanium metal and glass fibers, 19%.

2. **Salient Statistics--United States**:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production	W	W	W	W	W
Imports for consumption 2/	112	181	180	175	172
Exports e/	4	5	28	3	4
Shipments from Govt. stockpile excesses			None		
Consumption: Reported 2/	266	318	305	329	345
Apparent	W	W	W	W	W
Price, dollars per ton, yearend:					
f.o.b. Atlantic and Great Lakes ports, spot	415	475	475	515	515
Bulk, large lots, f.o.b. U.S. east coast	310	330	355	355	375
Synthetic, f.o.b. Mobile, AL	350	350	350	350	350
Stocks, mine, distributor and consumer, yearend	130	102	116	109	109
Employment, mine and mill 3/	336	382	410	385	373
Net import reliance 4/ as a percent of apparent consumption	W	W	W	W	W

3. **Recycling**: None.

4. **Import Sources (1983-86)**: Australia, 64%; Republic of South Africa, 17%; Sierra Leone, 16%; other, 3%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Rutile ore	601.5140	Free	Free
Synthetic rutile	603.7010	5.0% ad val.	30.0% ad val.

6. **Depletion Allowance**: 22% (Domestic), 14% (Foreign).

7. **Government Stockpile**:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Stockpile grade	106	39	-	-

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ See also Ilmenite and Titanium.
2/ Includes synthetic rutile.
3/ Employment at three sand deposit operations in Florida, which produced either rutile concentrate or a titanium mineral concentrate, where ilmenite and zircon were major coproducts, and where employees were not assigned to specific commodities.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ See page 184 for definitions.
6/ Excludes U.S. production.

Prepared by Langtry E. Lynd, telephone number (202) 634-1073.

8. **Events, Trends, and Issues:** Production of rutile increased in 1987. Production of synthetic rutile at the only U.S. synthetic rutile plant at Mobile, AL, also increased. Production of natural rutile in Australia, which in 1986 was the source of over 50% of the world's supply, rose about 10% in 1987. U.S. imports from Australia of natural and synthetic rutile totaled 130,000 tons, 18% more than in 1986. Synthetic rutile imports in 1987 were about 42,000 tons compared with 32,000 tons in 1986, and came almost entirely from Australia. It is estimated that in 1988 reported consumption of rutile will rise slightly to 350,000 tons, reflecting continued high demand for titanium dioxide (TiO_2).

On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Apartheid Act of 1986, rutile (including high-titanium slag) was certified by the U.S. Department of State as a strategic mineral essential for the economy or defense of the United States that is unavailable in adequate quantities from reliable and secure suppliers.

Mining of rutile is entirely from sand deposits which contain only a few percent of valuable minerals. While the discarded sand can be readily returned to the mined area, regraded and seeded to aid restoration of the environment, there has been continuing pressure to curtail sand mining in some areas.

Fewer environmental pollution problems are encountered when pigment is made from rutile rather than ilmenite. The chloride process, using a rutile feed, generates about 0.2 ton of waste per ton of TiO_2 product, while the alternate sulfate process, using ilmenite, generates about 3.5 tons of waste per ton of product. Producing synthetic rutile from ilmenite results in about 0.7 ton of waste, mainly iron oxide, per ton of product. Direct chlorination of ilmenite generates about 1.2 tons of waste, mainly ferric chloride, per ton of TiO_2.

In response to the continued high demand for TiO_2 pigments, rutile production in Sierra Leone was expanded 30% in 1987 to about 140,000 tons per year.

In Western Australia, two new synthetic rutile plants were put into production, one near Geraldton, with a capacity of 124,000 tons per year, and the other at Capel, with a 110,000-ton-per-year capacity, bringing total Australian synthetic rutile capacity to about 300,000 tons per year.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production		Reserves [5]	Reserve Base [5]
	1986	1987 [e]		
United States	W	W	300	1,700
Australia	243	270	6,100	12,400
Brazil	1	1	80,000	104,000
India	8	9	5,000	5,000
Italy	-	-	-	24,000
Sierra Leone	107	125	2,200	2,200
South Africa, Republic of	61	62	4,300	5,200
Sri Lanka	8	9	900	900
Centrally Planned Economies [e]	11	11	3,000	3,000
World Total (may be rounded)	[6]439	[6]487	102,000	158,000

Of the 12 million tons reserve base in Australia, about 3 million tons on the east coast cannot be mined because of environmental concerns.

10. **World Resources:** Identified world resources of rutile (including anatase) total about 200 million tons of contained TiO_2. Major rutile resources occur in Australia, India, Italy, Sierra Leone, the Republic of South Africa, and the United States. The Brazilian resources are mainly anatase.

11. **Substitutes:** Ilmenite, titaniferous slag, and synthetic rutile made from ilmenite may be used instead of natural rutile for making pigment, metal, or welding rod coatings.

SALT

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: The quantity of all forms of salt sold or used by producers in 1987 decreased slightly compared with that of 1986, and the value decreased from $665 million in 1986 to $625 million in 1987. Thirty-four companies operated 69 plants in 15 States, with the 9 largest companies representing more than 80% of the salt sold or used.

The chemical industry consumed about 49% of the salt sold or used by producers. Approximately 96% of the salt used by the chemicals sector was for manufacturing chlorine and caustic soda. Salt for highway deicing accounted for about 26% of the domestic salt demand. The other major markets for salt, in decreasing order, were distributors, general industrial, agricultural, food processing, other, and water treatment.

The estimated percentage of salt sold or used by type was salt in brine, 50%; rock salt, 34%; vacuum and open pan, 9%; and solar evaporated salt, 7%.

2. Salient Statistics--United States: 1/

Salient Statistics--United States: 1/	1983	1984	1985	1986	1987 e/
Production	32,973	39,181	39,217	37,282	36,000
Sold or used by producers	34,573	39,225	40,067	36,663	35,700
Imports for consumption	5,997	7,545	6,207	6,665	5,600
Exports	517	820	904	1,165	500
Consumption, apparent	40,053	45,950	45,370	42,163	40,800
Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine/plant:					
Vacuum and open pan salt	87.39	92.78	92.66	91.27	93.00
Solar salt	21.47	19.67	23.10	23.76	25.00
Rock salt	13.43	13.78	15.15	14.51	14.75
Salt from brine	5.22	5.05	6.14	5.15	4.50
Stocks, producer, yearend e/ 2/	834	790	-	619	300
Employment, mine and plant	5,000	4,700	4,500	4,500	4,400
Net import reliance 3/ as a percent of apparent consumption	18	15	14	12	12

3. Recycling: None.

4. Import Sources (1983-86): Canada, 42%; Mexico, 23%; Bahamas, 14%; other, 21%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
In brine	420.92	3.7% ad val.	20% ad val.
In bulk	420.94	Free	26% ad val.
Other	420.96	Free	11¢/100 lbs

6. Depletion Allowance: 10% (Domestic), 10% (Foreign).

7. Government Stockpile: None.

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e/ Estimated.
1/ Excludes Puerto Rico.
2/ Reported stock data are incomplete. For apparent consumption and net import reliance calculations, changes in annual stock totals are assumed to be the difference between salt production and salt sold or used.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ See page 184 for definitions.

Prepared by Dennis S. Kostick, telephone number (202) 634-1177.

8. Events, Trends, and Issues: In February, a major salt producer, with operations in Michigan, North Dakota, and Ohio, purchased a solar salt facility in Utah. In April, the new owner put the facility on the market and by August, another major domestic salt producer announced its intention to purchase it, pending final approval by the U.S. Department of Justice.

Salt brine used for chlorine and caustic soda manufacture increased because of increased demand for these chloralkalis. The rise in demand was in response to growth in the alumina, pulp and paper, and caustic soda export markets. A chemical company began producing a new road deicer made of calcium-magnesium acetate (CMA), which is reportedly one-fifteenth as corrosive as salt. Although CMA costs about $400 per ton and rock salt sells for only about $15 per ton, tests proceeded on CMA as a salt substitute on roads in California, Michigan, and Wisconsin.

A 200- to 400-million-ton salt deposit was discovered in China in Jiangsu Province. The resource reportedly is the largest salt deposit ever found in that country. In Botswana, the Government formed a joint venture with a company in the Republic of South Africa to produce soda ash and salt from underground brines in the Sua Pan. The project was anticipated to produce 600,000 tons of salt annually.

An Alabama utility company planned to develop the Nation's first compressed-air energy storage facility in a salt dome near McIntosh, AL. Electricity from coal-fired generators will drive compressors to store the air in solution-mined salt formations during periods of low energy demand. The energy would be reclaimed during peak demand periods by passing the air through a combustion turbine to generate electricity. The facility would generate 50 megawatts of energy and have a storage capacity of 26 hours.

It is estimated that in 1988, domestic mine production of salt will be 36 million tons and U.S. apparent consumption will be 42 million tons.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States (sold or used)1/	36,663	35,700	Large	Large
Australia	6,800	7,000		
Canada	12,222	12,000		
France	7,808	7,600	Economic and subeconomic deposits of salt are substantial in principal salt-producing countries. The oceans comprise an inexhaustible supply of salt.	
Germany, Federal Republic of	12,300	12,000		
India	11,004	11,100		
Italy	4,444	4,500		
Mexico	7,200	7,500		
United Kingdom	7,800	7,600		
Other Market Economy Countries	29,895	30,000		
China	19,070	20,000		
Poland	5,400	5,400		
U.S.S.R.	17,700	17,700		
Other Centrally Planned Economies	13,916	14,000		
World Total (may be rounded)	192,222	192,000		

10. World Resources: World resources of salt are virtually unlimited. Domestic resources of rock salt and salt from brine are located in the northeast, central western, and southern Gulf Coast States. Saline lakes and solar evaporated salt facilities are close to populated regions in the Western United States. Nearly every country in the world has salt deposits or solar evaporation operations of various sizes.

11. Substitutes: There were no economic substitutes or alternates for salt. Calcium chloride and calcium-magnesium acetate, hydrochloric acid, and potassium chloride can be substituted for salt in deicing, certain chemical processes, or food flavoring, but at a higher cost.

SAND AND GRAVEL

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use:** Construction sand and gravel valued at $3.0 billion was produced by about 4,300 companies from about 5,800 operations in 50 States. Leading States in order of volume were California, Texas, Michigan, Arizona, Ohio, New York, Florida, Illinois, Alaska, and Washington, which accounted for about 50% of the total output. About 28% of this tonnage was used as aggregate in concrete for residential and nonresidential buildings, highways, bridges, dams, waterworks and airports, and other concrete products; 15% in roadbases and coverings; 10% as asphaltic concrete aggregates and other bituminous mixtures; 7% for construction fill; 2% was for railroad ballast, snow and ice control, and other miscellaneous uses; and 38% as other unspecified uses.

   Industrial sand and gravel valued at $366 million was produced by 92 companies from 162 operations in 38 States. Leading States in order of volume were Illinois, Michigan, New Jersey, California, and Texas. Their combined production represented 48% of the national total. About 40% of this tonnage was used as glassmaking sand, 21% as foundry sand, 7% as abrasive sand, 4% as hydraulic fracturing sand, 11% for other miscellaneous uses, and 17% as other unspecified uses.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Construction sand and gravel:					
Production	e/655,100	773,900	e/800,100	883,000	896,900
Imports for consumption	123	151	246	205	200
Exports	1,303	1,845	1,513	1,166	1,200
Consumption, apparent	e/653,900	772,200	e/798,800	882,039	895,900
Price, average value, dollars per ton	e/2.90	2.90	e/3.05	3.11	3.35
Stocks, yearend	Not available				
Employment, quarry and mill e/	45,000	46,000	46,000	47,000	47,000
Net import reliance 1/ as a percent of apparent consumption	Net exporter				
Industrial sand and gravel:					
Production	26,620	29,380	29,430	27,420	27,700
Imports for consumption	58	26	81	88	80
Exports	1,047	1,193	866	849	800
Consumption, apparent	25,600	28,200	28,600	26,659	26,980
Price, average value, dollars per ton	12.59	12.84	12.71	13.10	13.20
Stocks, yearend	Not available				
Employment, quarry and mill e/	1,500	1,600	1,600	1,600	1,600
Net import reliance 1/ as a percent of apparent consumption	Net exporter				

3. **Recycling:** Asphalt road surfaces and cement concrete surfaces were recycled on a limited but increasing basis.

4. **Import Sources (1983-86):** Construction sand and gravel: Canada, 82%; Antigua, 7%; other, 11%. Industrial sand and gravel: Australia, 46%; Antigua, 19%; Japan, 14%; other, 21%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
95% or more silica and not more than 0.6% iron oxide	513.11	Free	$2.00/lt
Other	513.14	Free	Free

6. **Depletion Allowance:** (Domestic and Foreign)
   Sand and Gravel: Common varieties 5%, industrial sand or pebbles 14%.

7. **Government Stockpile:** None.

e/ Estimated. NA Not available.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ See page 184 for definitions.

Prepared by Valentin V. Tepordei, telephone number (202) 634-1185.

8. Events, Trends, and Issues: Construction sand and gravel output increased 2% in 1987. It is estimated that 1988 domestic production and U.S. apparent consumption will be about 900 million tons each.

Industrial sand and gravel output increased in 1987 by about 1%. It is estimated that 1988 domestic production and U.S. apparent consumption will be 28 million and 27 million tons, respectively.

The sand and gravel industry continued to be concerned with safety regulations and environmental restrictions in 1987. Shortages in urban and industrialized areas were expected to continue to increase due to local zoning regulations and land development alternatives. This was expected to continue to cause a movement of sand and gravel operations from high population centers.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves and Reserve Base 2/
	1986	1987 e/	
United States	910,420	924,600	The reserve and reserve base are controlled largely by land use and/or environmental constraints. Local shortages of sand or gravel are common.
Other countries	NA	NA	

10. World Resources: Sand and gravel resources of the world are large. However, owing to their geographic distribution, environmental restrictions, and quality requirements for some uses, their extraction is sometimes uneconomic. The most important commercial sources of sand and gravel have been river flood plain, river channel, and glacial deposits. Marine deposits could become important in the future. Quartz-rich sand and sandstones, the main source of industrial silica sand, occur throughout the world.

11. Substitutes: Crushed stone remains the predominant alternative for construction aggregate use. Silica sand continues to be the major material used for glassmaking and for foundry and molding sands; alternates are zircon, olivine, staurolite, and chromite sands.

SCANDIUM

(Data in kilograms of scandium oxide content, unless noted)

1. Domestic Production and Use: In 1987, scandium was recovered as a minor byproduct; 1) from the mineral thortveitite, contained in screenings of fluorite mined previously at Crystal Mountain, MT; 2) from a scandium concentrate extracted during the recovery of uranium from copper tailings at a copper mine in Bingham Canyon, UT; and 3) from a tungsten concentrate derived from molybdenum ores previously mined at Climax, CO. Five processing companies, of which two were in Arizona, and one each in Colorado, Iowa, and New Jersey, produced refined scandium products. Scandium used in the United States, principally as the oxide or metal, came primarily from domestic sources. The principal uses for scandium were in laser rods and high-intensity mercury vapor lamps.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, refinery	NA	NA	W	W	W
Imports for consumption		Not available			
Exports		Not available			
Consumption	NA	NA	68	51	50
Price, yearend, dollars:					
per kilogram, oxide 99.9%	5,200	13,000	13,400	9,500	9,500
per gram, ingot, metal 1/	NA	NA	179.20	179.20	146.80
per gram, sublimed, metal 2/	NA	NA	214.00	214.00	173.90
Stocks		Not available			
Employment		Not available			
Net import reliance 3/ as a percent of apparent consumption		Not available			

3. Recycling: Minor.

4. Import Sources (1983-86): Not available.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Rare-earth metals (including scandium)	632.38	3.7% ad val.	25% ad val.
Alloys of rare-earth metals (including scandium)	632.78	32¢/lb	$2/lb+ 25% ad val.
Rare-earth oxides except cerium oxide (including scandium oxide)	423.00	3.7% ad val.	25% ad val.

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Vacuum remelted, 99.9% purity.
2/ Dendritic lump, 99.9% purity.
3/ Defined as imports - exports + adjustments for Government and industry stocks changes.
4/ See page 184 for definitions.

Prepared by James B. Hedrick, telephone number (202) 634-1058.

8. Events, Trends, and Issues: Demand for scandium decreased slightly in 1987. The lower demand was attributed to decreased consumption in laser applications, the largest end use. Although research continued on scandium-containing laser crystals, lasers had not yet developed into a long-term market. The availability of domestic scandium improved as a principal producer reopened its facilites in Utah under new ownership in February. The price of scandium products decreased somewhat in 1987 as a result of the improved supply situation. It is probable that the use of scandium will increase if the price decreases substantially.

   Improved knowledge of scandium's properties may lead to new commercial applications. A scandium deposit, discovered in Norway in 1987, was reported to contain high concentrations of scandium.

   Scandium was listed as a "high-tech" metal by the U.S. Department of Defense and was designated as a priority material for new studies and policy formulation.

9. World Mine Production, Reserves, and Reserve Base: China, the United States, and the U.S.S.R. were the principal mine producers of scandium in 1987. Although scandium occurs in many rocks, it has not been found in sufficient concentration to allow the calculation of a reserve or reserve base.

10. World Resources: Resources of scandium, considered in relation to actual and potential demand, are abundant. Scandium is widely dispersed in the earth's crust and trace amounts are found in many rocks; it is rarely concentrated in nature, but a small number of acid-rich pegmatites have been mined for thortveitite, one of the few minerals in which scandium is an essential constituent. Scandium is present in some fluorite, iron, phosphate, titanium, tungsten, uranium, zinc, and zirconium ores. Some of these ores may contain as much as 5,000 parts per million (0.5% by weight) of scandium, but the concentration is usually much lower. Significant quantities of scandium occur in domestic uranium and tungsten ores, and in phosphate rock, but have not been recovered on a large scale because of limited demand.

11. Substitutes: The properties of scandium are somewhat similar to those of the rare-earth elements, but in special applications such as lighting and lasers, it is generally not subject to substitution.

SELENIUM

(Data in metric tons of selenium content, unless noted)

1. Domestic Production and Use: Primary selenium was recovered from anode slimes generated in the electrolytic refining of copper. Three copper refineries, one located in Utah, and two in Texas, accounted for the domestic production of primary selenium. High-purity selenium metal and various selenium compounds were produced by two of the refineries and other processors. The estimated consumption of selenium by end use was as follows: electronic and photocopier components, 35%; glass manufacturing, 25%; chemical and pigments, 28%; and other, 12%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, refinery	354	254	W	W	W
Imports for consumption, metal and compounds	297	377	401	463	500
Exports, metal, waste and scrap	93	123	154	161	155
Consumption, apparent	578	478	W	W	W
Price, dealers', average, dollars per pound, 100-pound lots, commercial grade	3.87	9.02	7.50	5.60	6.43
Stocks, producer, (refined metal only) yearend	67	97	W	W	W
Employment	Not available				
Net import reliance 1/ as a percent of apparent consumption	39	47	W	W	W

3. Recycling: There is no domestic production of secondary selenium. Scrap xerographic materials were exported to Canada and the United Kingdom for recovery of the contained selenium. An estimated 100 tons of secondary metal was imported in 1987.

4. Import Sources (1983-86): Canada, 30%; United Kingdom, 24%; Japan, 17%; Belgium-Luxembourg, 15%; other, 14%.

5. Tariff:

Tariff:	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Selenium metal	632.40	Free	Free
Selenium dioxide and salts	420.50 & 420.52	Free	Free
Other selenium compounds	420.54	3.7% ad val.	25.0% ad val.

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ See page 184 for definitions.
3/ Excludes production in the United States, Other Market Economy Countries, and Centrally Planned Economies.
4/ Excludes Yugoslavia and Centrally Planned Economies.

Prepared by Neldon L. Jensen, telephone number (202) 634-1058.

8. **Events, Trends and Issues:** Domestic production of refined selenium increased from the 1986 level, and net imports rose by 14%. The U.S. dealer price for commercial-grade selenium was $5.40 to $5.65 in January, then increased steadily to $7.35 to 7.60 in November.

Selenium is a toxic metal that can pose environmental problems in some circumstances. One such instance was the discovery in 1986 that evaporative concentration of selenium had poisoned farm drainage water collecting in the Kesterson National Wildlife Refuge, in California. Federal and State agencies continued in 1987 their investigation into ways of correcting the problem.

9. **World Refinery Production, Reserves, and Reserve Base:**

	Refinery Production		Reserves 2/	Reserve Base 2/
	1986	1987 e/		
United States	W	W	12,000	19,000
Belgium	70	70	-	-
Canada	334	350	11,000	15,000
Chile	40	40	17,000	33,000
Finland	17	17	-	-
Japan	427	500	-	-
Mexico	40	40	4,000	5,000
Peru	12	20	3,000	7,000
Sweden	70	70	-	-
Yugoslavia	45	45	NA	1,000
Zambia	15	15	7,000	7,000
Other Market Economy Countries	NA	NA	25,000	25,000
Centrally Planned Economies	NA	NA	NA	18,000
World Total (may be rounded)	3/ 1,070	3/ 1,170	4/ 80,000	130,000

10. **World Resources:** In addition to the above large reserve base of byproduct selenium which is contained in identified copper deposits of economic grade, 2.5 times this quantity of byproduct metal is believed to exist in copper or other metal deposits that are undeveloped, of uneconomic grade, or as yet undiscovered. Coal contains an average of 1.5 parts per million of selenium, but although the selenium content of coal deposits is about 80 times the content of identified economic copper deposits, recovery of selenium from coal appears unlikely in the foreseeable future.

11. **Substitutes:** High-purity silicon is the major substitute for selenium in its application as a semiconductor in rectifiers, and has replaced selenium in rectifier usage in high-voltage equipment. Other inorganic semiconductor materials, such as silicon, cadmium, tellurium, gallium, and arsenic, as well as organic photoconductors, may substitute for selenium in photoelectric applications. Other substitutes include cerium oxide in glass manufacturing, tellurium in pigment and rubber compounding, and tellurium, bismuth, and lead in the production of free-machining metals.

SILICON

(Data in thousand short tons of silicon content, unless noted)

1. Domestic Production and Use: Estimated value of silicon metal and alloys (excluding semiconductor grade silicon) produced in the United States in 1987 was $380 million. Ferrosilicon was produced by 8 companies in 12 plants while production of silicon metal was divided among 7 companies in 8 plants. Most of the ferrosilicon and silicon metal plants were located east of the Mississippi River or in the Pacific Northwest. Most ferrosilicon was consumed in the ferrous foundry and steel industries located predominantly in the eastern half of the United States. The main consumers of silicon metal were aluminum producers located throughout the United States and the chemical industry. End uses of silicon were: Transportation, 32%; chemicals, 21%; machinery, 17%; construction, 13%; and other, 17%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production	333	454	400	335	370
Imports for consumption	133	121	154	191	190
Exports	9	20	9	11	20
Consumption, apparent	480	551	533	527	550
Price, average, cents per pound Si:					
Ferrosilicon 50% Si	42.1	42.9	44.6	40.0	40.3
Silicon metal max. 1% Fe	57.2	62.9	63.3	62.0	62.0
Stocks, producer and consumer, yearend	86	90	102	90	80
Employment, plant e/	2,500	2,600	2,500	2,400	2,400
Net import reliance 1/ as a percent of apparent consumption	31	18	25	36	33

3. Recycling: Insignificant.

4. Import Sources (1983-86): Brazil, 22%; Canada, 19%; Norway, 16%; Venezuela, 14%; other, 29%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ferrosilicon, 8-60% Si	606.35	Free	2.0¢/lb. Si
Ferrosilicon, 60-80% Si:			
Over 3% Ca	606.36	1.1% ad val.	11.5% ad val.
Other	606.37	1.5% ad val.	11.5% ad val.
Ferrosilicon, 80-90% Si	606.39	1.9% ad val.	9.0% ad val.
Ferrosilicon, over 90% Si	606.40	5.8% ad val.	40.0% ad val.
Silicon, 96.0-99.0% Si	632.86	9.0% ad val.	45.0% ad val.
Silicon, 99.0-99.7% Si	632.42	5.3% ad val.	21.0% ad val.
Silicon, over 99.7% Si	632.43	3.7% ad val.	25.0% ad val.

6. Depletion Allowance: Quartzite, 14% (Domestic and Foreign); gravel, 5% (Domestic and Foreign).

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Silicon carbide, crude short tons, gross weight	29,000	72,950	-	7,600

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e/ Estimated.

1/ Defined as imports - exports + adjustments for Government and industry stock changes.

2/ See page 184 for definitions.

Prepared by Clark R. Neuharth, telephone number (202) 634-1015.

8. **Events, Trends, and Issues:** Demand for silicon ferroalloys follows closely overall iron and steel production whereas demand for silicon metal largely depends on the health of the aluminum and chemical industries. Owing to slightly increased demand by the iron and steel and aluminum industries, prices for most silicon products edged higher in the third quarter after dropping earlier in the year. For example, the published price, on a per pound of contained silicon basis, for domestically produced 75% ferrosilicon was lowered on May 14, from 40.0-47.0 cents to 37.85-40.0 cents and raised on August 14 and August 27 to 38.75-42.0 cents and 42.0 cents, respectively. The published price for domestically produced 50% ferrosilicon was also adjusted from 40.0-45.0 cents to 42.0 cents. The published prices for most speciality silicon ferroalloys, such as regular grade magnesium ferrosilicon containing 5% magnesium and magnesium ferrosilicon with 9% magnesium, were essentially unchanged. Posted prices for most imported silicon materials were 5 to 7 cents lower than those for domestically produced materials in January. However, import prices steadily increased, bringing them within 2 to 3 cents of domestic list prices by the fourth quarter.

It is estimated that in 1988 domestic production of silicon metal and alloys will be 350,000 tons and U.S. apparent consumption will be 550,000 tons.

As a result of a Congressionally mandated general review of the Generalized System of Preferences (GSP) program, silicon metal imports from Brazil containing 99.0% to 99.7% silicon were exempt from GSP status effective July 1. The GSP is a program of tariff preferences granted by the United States to developing countries to assist in their economic development. In 1986, silicon metal imports from Brazil accounted for over 30% of the U.S. import market in the 99.0% to 99.7% category, which exceeded the 25% maximum allowed under GSP guidelines. The exemption from GSP status, along with the weakness of the dollar versus Japanese and Western European currencies, slowed silicon metal imports from Brazil significantly in 1987.

In April, the U.S. Government imposed additional 100% tariffs on certain electronic goods from Japan representing approximately $300 million in annual imports. Previous tariffs had been only 2% to 5%. The move came in retaliation to alleged infractions of a year-old semiconductor chip agreement between the United States and Japan. Federal funding budgeted for photovoltaic research amounted to $20.4 million in 1988 compared with an actual outlay of $40.4 million in 1987. The U.S. Department of Commerce continued controls on exports to the U.S.S.R. of both electronic-grade polycrystalline and monocrystalline silicon.

9. **World Production, Reserves, and Reserve Base:**

	Production		Reserves and Reserve Base 2/
	1986	1987 e/	
United States	335	370	The reserves and reserve base in most major producing countries are ample in relation to demand. Quantitative estimates are not available.
Brazil	238	240	
Canada	86	80	
France	185	170	
Italy	49	50	
Japan	65	60	
Norway	403	400	
South Africa, Republic of	107	100	
Spain	109	90	
Yugoslavia	116	110	
Other Market Economy Countries	378	370	
U.S.S.R.	600	600	
Other Centrally Planned Economies	350	360	
World Total	3,021	3,000	

10. **World Resources:** The world and domestic resources for making silicon metal and alloys are abundant and in most alloy metal producing countries are adequate to supply world requirements for many decades.

11. **Substitutes:** Various metals and alloys, such as aluminum and silicomanganese, can be substituted for silicon in some applications. Germanium is the principal substitute for silicon in semiconductor and infrared applications.

SILVER

(Data in million troy ounces of silver content, unless noted)

1. Domestic Production and Use: Silver was produced from about 120 mines in 15 States and had an estimated value of $270 million. Five States accounted for 86% of the 1987 mine production: Idaho, 34%; Nevada, 23%; Montana, 14%; Arizona, 9%; and Utah, 6%. Ten mines produced about 65% of the silver mined. There were 22 principal refiners of commercial-grade silver, located primarily in northeastern States. Fabricating and manufacturing firms were estimated to number over 5,000. The photographic industry is located primarily in New York and other end-use manufacturing firms are mainly in Connecticut, New York, Rhode Island, and New Jersey. Silver consumption in 1987 by end use was: photography, 45%; electrical and electronic products, 26%; sterlingware, electroplated ware, and jewelry, 13%; brazing alloys and solders, 6%; other, 10%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Mine	43.4	44.6	39.4	34.2	38.0
Refinery--Primary	57.8	59.3	53.8	42.4	45.0
Secondary (old scrap)	29.4	27.8	27.8	23.2	24.0
Imports for consumption 1/	179.9	115.0	152.6	144.9	95.0
Exports 1/	32.0	24.4	24.8	25.1	25.0
Shipments from Govt. stockpile excesses	-	-	-	10.2	18.0
Consumption: Reported--Industrial	116.4	114.8	118.6	118.9	120.0
Coinage	2.1	2.7	0.4	7.4	12.0
Apparent 2/	178.8	172.8	162.3	200.6	144.0
Price, average, New York, dollars per ounce	11.44	8.14	6.14	5.47	7.20
Stocks, yearend: Treasury Department 3/	34.6	31.9	32.6	33.8	40.0
Industry, COMEX, CBT 4/	168.7	158.8	191.6	178.4	185.0
Department of Defense	0.1	0.3	0.5	2.5	2.0
Employment, mine and mill 5/	2,400	2,600	3,000	2,200	2,400
Net import reliance 6/ as a percent of apparent consumption	59	58	59	71	57

3. Recycling: About 24 million ounces of silver was recovered from old scrap in 1987, equivalent to 20% of reported consumption. Another 45 million ounces was recovered from new scrap.

4. Import Sources (1983-86): Canada, 28%; Mexico, 27%; United Kingdom, 16%; Peru, 12%; other, 17%.

5. Tariff: No duties were imposed on imports of unrefined silver or refined bullion. There were duties on items such as platinum- and gold-plated unwrought or semimanufactured silver, but these items constituted a minor portion of U.S. imports.

6. Depletion Allowance: 15% (Domestic), 14% (Foreign).

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Silver	-	113.7	13.0	16.3

e/ Estimated.
1/ Excludes coinage.
2/ Domestic primary metal production plus recovery from old silver scrap plus net imports plus net changes in reported stocks; also includes net bullion purchased for investment purposes.
3/ Balance in Mint only.
4/ Industry: Refiner, fabricator, and dealer. COMEX: Commodity Exchange, Inc., New York. CBT: Chicago Board of Trade.
5/ Source, Mine Safety and Health Administration.
6/ Defined as imports - exports + adjustments for Government and industry stock changes.
7/ Includes silver recoverable as a byproduct of base-metal ores.
8/ See page 184 for definitions.

Prepared by Robert G. Reese, telephone number (202) 634-1070.

8. Events, Trends, and Issues: U.S. mine production of silver increased in 1987, owing in part to an increase in the silver price, and to the results of cost-cutting measures and productivity improvements adopted by mining companies over the past several years. The increased production was also due to the attainment of full production at a number of byproduct silver mines opened in late 1986, and to the opening of several new byproduct silver mines during the year. Most of these new mines, like most of the new silver-producing mines opened the past few years, were low-grade low-cost gold mines, which recover precious metals using heap leaching. Silver production in the Coeur d'Alene area of Idaho, traditionally the Nation's largest silver producing region, remained depressed following the closure of a majority of the area's mines in 1986 owing to the low silver price. However, one of the region's largest producers reopened in May 1987; in 1985, its last full year of production, the mine had been the largest U.S. silver mine.

   It is estimated that in 1988 domestic mine production of silver will be about 40 million ounces.

   In 1987, the average silver price increased for the first time in 4 years. In general, the price remained in the $5.00 - $6.00 range throughout the first 4 months of the year, and in the $7.00 - $8.00 range during the remainder of the year. Several times during the last 8 months of 1987, the price rose above $8.00 in response to events such as the fall in the stock market in October. The price began the year at $5.44. The low price of $5.36 occurred on January 7; the peak price of $10.20 occurred on April 27. The average daily price increased from $5.47 in 1986 to $7.20 in 1987. Major factors believed to have influenced the silver price were the relative value of the U.S. dollar in relation to other currencies, the U.S. trade deficit, fears of an increased U.S. inflation rate, the stock market drop in late October, and chart and/or computer-guided trading by investor funds.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 7/8/	Reserve Base 7/8/
	1986	1987 e/		
United States	34.2	38.0	920	1,800
Canada	39.2	40.0	1,160	1,400
Mexico	75.2	75.0	1,370	1,400
Peru	61.9	62.0	680	950
Other Market Economy Countries	121.5	125.0	1,900	3,200
U.S.S.R.	48.2	48.0	1,400	1,600
Other Centrally Planned Economies	39.6	40.0	400	400
World Total (may be rounded)	419.8	428.0	7,830	10,800

10. World Resources: Approximately two-thirds of world silver resources are associated with copper, lead, and zinc deposits. The remaining one-third is in vein deposits in which silver is the principal metallic component. While most recent discoveries have been primarily gold and silver deposits, significant future reserves and resources are expected to be associated with major base metal discoveries that contain byproduct silver.

11. Substitutes: Aluminum and rhodium substitute for silver in mirrors and other reflecting surfaces. Tantalum can be used in place of silver for surgical plates, pins, and sutures. Stainless steel is an alternate material used widely in the manufacture of table flatware. Some of the batteries being developed may replace silver batteries in some applications. Silverless black and white film, film with reduced silver content, and xerography are alternatives to some uses of silver in photography.

SODIUM CARBONATE (SODA ASH)

(Data in thousand short tons, unless noted)

1. **Domestic Production and Use:** The domestic soda ash industry was comprised of five companies operating five plants in Wyoming, and one company operating two plants in California. The industry, with an annual nameplate capacity of 10.6 million tons, operated at about 80% of nameplate capacity. Sodium sulfate, potassium chloride, potassium sulfate, borax, and other minerals were produced as coproducts from sodium carbonate production in California. The total estimated value of domestic soda ash produced in 1987 was $600 million.

   The distribution of soda ash by end use was glass, 53%; chemicals, 20%; soap and detergents, 10%; water treatment, 4%; flue gas desulfurization and pulp and paper, 3% each; and other, 7%.

2. **Salient Statistics—United States:**

Salient Statistics—United States:	1983	1984	1985	1986	1987 e/
Production, natural and synthetic 1/	8,467	8,511	8,511	8,438	8,500
Imports for consumption	20	17	56	106	120
Exports	1,636	1,648	1,747	2,049	2,100
Consumption, apparent (natural and synthetic)	6,868	6,865	6,750	6,590	6,584
Price: Quoted, yearend, soda ash, natural, dense, bulk, f.o.b. Green River, WY, dollars per ton	69.00	79.00	83.00	83.00	87.00
F.o.b. Searles Valley, CA, same basis	92.25	109.25	113.25	113.25	117.25
F.o.b. Syracuse, NY, synthetic, same basis	132.00	132.00	132.00	132.00	-
Average sales value (natural source), f.o.b. mine or plant, dollars per ton	76.95	67.00	67.82	65.29	68.00
Stocks, producer, yearend	307	322	428	294	230
Employment, mine and plant	3,400	3,400	3,200	3,100	2,900
Net import reliance 2/ as a percent of apparent consumption		Net exporter			

3. **Recycling:** There is no recycling of soda ash by producers; however, glass container producers are using cullet glass, thereby reducing soda ash consumption.

4. **Import Sources (1983-86):** Canada, 99%; other, 1%. The increases in imports are mainly stock transfers and shipments between a U.S. soda ash producer and its Canadian soda ash subsidiary.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Calcined (soda ash)	420.84	1.2% ad val.	8.5% ad val.
Hydrated and sesquicarbonate	420.86	0.1¢/lb.	0.25¢/lb.

6. **Depletion Allowance:** 14% (Domestic), 14% (Foreign). For natural only.

7. **Government Stockpile:** None.

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e/ Estimated. NA Not available.
1/ Natural and synthetic, 1983-86; natural only, 1987.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ The reported quantities are sodium carbonate only. About 1.8 tons of trona yields 1 ton of sodium carbonate.
4/ See page 184 for definitions.
5/ Includes synthetic.
6/ From trona, nahcolite, and dawsonite sources.
7/ Excludes Botswana, Chad, and Uganda.
8/ Excludes Botswana, Chad, Kenya, and Uganda.

Prepared by Dennis S. Kostick, telephone number (202) 634-1177.

8. Events, Trends, and Issues: The third largest soda ash facility in Wyoming was sold twice during the year. The second owner, a major Western European synthetic soda ash producer, may export its U.S.-produced soda ash to several of its Far East customers, or ship the soda ash to Europe to possibly displace a similar quantity of synthetic product produced at its European facility. The transaction is the third total or partial acquisition of U.S. soda ash operations by foreign investors. A fourth acquisition, by an Australian mineral company interested in Owens Lake in California, was pending near yearend.

Domestic demand showed improvement in the latter part of the year, especially in uses in which soda ash substituted for more expensive caustic soda. The supply of soda ash was tight at certain times and consumers accepted the $4 per ton price increase at midyear.

The export market for U.S. soda ash exceeded 2 million tons for the second consecutive year. China remained the largest consumer of U.S. material.

It is estimated that in 1988 domestic mine production of soda ash will be 8.55 million tons and U.S. apparent consumption will be 6.6 million tons.

9. World Mine Production, Reserves, and Reserve Base:

(Natural sources):	Mine Production 1986	Mine Production 1987 e/	Reserves 3/ 4/	Reserve Base 3/ 4/
United States	5/8,438	8,500	6/25,500,000	6/42,700,000
Botswana	NA	NA	400,000	NA
Chad	NA	NA	8,000	NA
Kenya	250	250	56,000	NA
Mexico	200	180	200,000	500,000
Turkey	-	-	216,000	260,000
Uganda	NA	NA	18,000	NA
World Total (may be rounded)	7/8,890	7/8,930	26,400,000	8/43,500,000

10. World Resources: Soda ash is obtained from trona and sodium carbonate-rich brines. The world's largest deposit of trona is in the Green River Basin of Wyoming. About 52 billion tons of identified soda ash resources could be obtained from the 62 billion tons of bedded trona 3/ and the 52 billion tons of interbedded or intermixed trona and halite that are in beds more than 4 feet thick. Underground room-and-pillar mining, using a combination of conventional, continuous, and shortwall mining equipment, is the dominant method of mining Wyoming trona ore. The method has a 45% average extraction efficiency rate, which is higher than a 30% average extraction efficiency rate expected from solution mining. Dredging of sodium decahydrate crystals from tailing ponds, which are secondary sodium carbonate resources, is another mining method being used. About 37 billion tons of reserve base soda ash could be obtained from the 40 billion tons of halite-free trona and the 27 billion tons of interbedded or intermixed trona and halite that are in beds more than 6 feet thick. Two potential sources of soda ash, nahcolite (sodium bicarbonate) and dawsonite (sodium-aluminum carbonate), are associated with oil shale in northwestern Colorado. Identified resources of 32 billion tons of nahcolite and 19 billion tons of dawsonite (equivalent to 27 billion tons of sodium carbonate resources) are available as a byproduct of oil shale processing. An undetermined quantity of sodium carbonate-bearing minerals and brines is located in deep evaporite beds near Duchesne, UT. If the deposit is found to be economic to develop, solution mining, rather than conventional mining, would probably be the preferred method because of the depths.

There are at least 62 identified natural sodium carbonate deposits in the world, some of which have been quantified. The countries and number of deposits include: Australia (1), Bolivia (2), Botswana (1), Brazil (1), Canada (3), Chad (1), China (9), Egypt (1), Ethiopia (1), India (2), Kenya (3), Mexico (1), Namibia (1), Niger (1), Pakistan (1), the Republic of South Africa (1), Tanzania (5), Turkey (1), Uganda (1), the U.S.S.R. (4), the United States (20), and Venezuela (1).

11. Substitutes: Caustic soda can be substituted for soda ash in certain uses. An alternate source of soda ash is nahcolite, but commercial development of oil shale mining with byproduct nahcolite and dawsonite recovery is uncertain.

SODIUM SULFATE

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: Production of sodium sulfate decreased for the fourth consecutive year. The natural sodium sulfate industry, comprised of three producers operating a total of four plants in California, Texas, and Utah, operated at about 71% of total nameplate capacity. Approximately 52% of total sodium sulfate production was a byproduct from various chemical and rayon manufacturing facilities. Total production of sodium sulfate was valued at about $70 million in 1987.

   End uses of sodium sulfate were soap and detergents, 46%; pulp and paper, 36%; and glass and miscellaneous, 18%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Natural	423	435	389	396	360
Synthetic 1/	432	437	446	402	390
Imports for consumption	343	265	195	188	150
Exports	91	76	119	111	120
Consumption, apparent (natural and synthetic)	1,089	1,050	939	834	792
Price: Quoted, sodium sulfate-100% Na_2SO_4, bulk, f.o.b. works, East, dollars per ton	103.00	113.00	113.00	113.00	113.00
Average sales value (natural source), f.o.b. mine or plant, dollars per ton	93.30	92.16	92.19	86.11	85.00
Stocks, producer, yearend, natural	48	59	31	72	60
Employment, wells and plants	450	420	400	400	350
Net import reliance 2/ as a percent of apparent consumption	21	17	11	4	5

3. Recycling: There was some recycling of sodium sulfate by consumers, particularly in the pulp and paper industry, but no recycling by sodium sulfate producers.

4. Import Sources (1983-86): Canada, 88%; Mexico, 7%; Belgium, 2%; Federal Republic of Germany, 2%; other, 1%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude (salt cake)	421.42	Free	Free
Anhydrous	421.44	33¢/l.t.	$3/l.t.
Crystallized (Glauber's salt)	421.46	2.5% ad val.	4% ad val.

6. Depletion Allowance: 14% (Domestic), 14% (Foreign)--natural only.

7. Government Stockpile: None.

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e/ Estimated. NA Not available.
1/ Source: Bureau of the Census.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.
4/ Excludes Argentina and Iran.
5/ Excludes Argentina, Iran, and Turkey.

Prepared by Dennis S. Kostick, telephone number (202) 634-1177.

8. Events, Trends, and Issues: A domestic natural sodium sulfate producer placed one of its plants, which had an annual nameplate capacity of 70,000 tons, on indefinite inactive status because of problems with brine dilution and market conditions. This reduced the annual nameplate capacity of the natural sodium sulfate industry to 440,000 tons. The decline in the popularity of powdered detergents in favor of liquid detergents, which do not contain sodium sulfate in their formulation, has contributed to the decline in total sodium sulfate consumption. With the development of washing machines that cleanse using only ultrasonic waves, the demand for sodium sulfate, and all other ingredients used in powdered or liquid detergents, may be reduced significantly.

Despite declining production and consumption in the United States, other countries are actively developing new sodium sulfate operations or expanding and upgrading current facilities. These countries include Egypt, the Netherlands, Spain, the United Kingdom, and the U.S.S.R. In the United States at Owens Lake in California, an Australian mineral company signed a letter of intent to acquire a sodium mineral resource, which contains about 12 million tons of sodium sulfate. An interim feasibility study was completed with the intent to produce 500,000 tons of sodium sulfate per year.

It is estimated that in 1988 domestic mine production of sodium sulfate will be 300,000 tons and U.S. apparent consumption will be 750,000 tons.

9. World Mine Production, Reserves, and Reserve Base: (Natural sources)

	Mine production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States	396	360	945,000	1,500,000
Argentina	39	40	NA	NA
Canada	409	400	92,000	300,000
Iran	e/13	10	NA	NA
Mexico	441	440	182,000	250,000
Spain	468	480	200,000	300,000
Turkey	99	100	110,000	NA
Other Market Economy Countries	2	10	207,000	250,000
U.S.S.R.	397	400	2,000,000	2,500,000
World Total (may be rounded)	2,264	2,240	4/3,740,000	5/5,100,000

10. World Resources: Sodium sulfate resources are sufficient to last hundreds of years at the present rate of world consumption. In addition to the above countries, identified resources of sodium sulfate exist in Botswana, Egypt, Italy, Mongolia, Romania, and the Republic of South Africa. Sodium sulfate may also be obtained as a byproduct from the production of ascorbic acid, boric acid, cellulose, chromium chemicals, lithium carbonate, rayon, resorcinol, and silica pigments. The quantity and availability of byproduct sodium sulfate is dependent on the production capabilities of the primary industries and the sulfate recovery rates.

11. Substitutes: In pulp and paper, emulsified sulfur and caustic soda can replace sodium sulfate. In detergents, a variety of products can substitute for sodium sulfate. In glassmaking, soda ash or calcium sulfate have been substituted for sodium sulfate with less than perfect results.

STONE (CRUSHED) 1/

(Data in million short tons, unless noted)

1. **Domestic Production and Use:** Crushed stone valued at $4.4 billion was produced by 1,790 companies operating 3,560 quarries in 49 States. Leading States in order of production were Pennsylvania, Florida, Texas, Georgia, and Virginia, which accounted for nearly 32% of the output. About 63% of this tonnage was used as construction aggregate, mostly for highway and road construction and maintenance; 11% was used for cement and lime manufacturing; 3% in agriculture; 1% for metallurgical process; 2% for a variety of industrial uses; and 20% for other miscellaneous and unspecified uses. Of the crushed stone produced in 1987, about 72% was limestone and dolomite; 15% granite; 8% traprock; 2% sandstone; and the remaining 3% was shell, marl, volcanic cinder, slate, and other.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production	862	e/956	1,001	e/1,023	1,051
Imports for consumption	3	3	3	3	3
Exports	2	2	2	3	3
Consumption, apparent	863	e/957	1,002	e/1,023	1,051
Price, average value, dollars per ton	3.86	e/3.93	4.05	e/4.16	4.19
Stocks, yearend		Not available			
Employment, quarry and mill e/ 2/	52,000	53,000	54,000	55,000	55,000
Net import reliance 3/ as a percent of apparent consumption			None		

3. **Recycling:** Asphalt-crushed stone road surfaces and, to a lesser extent, cement concrete surfaces were recycled on a limited but increasing basis in some States.

4. **Import Sources (1983-86):** Canada, 85%; Mexico, 3%; other, 12%.

5. **Tariff:** All crushed stone was imported free from most favored nations only, starting January 1, 1987.

6. **Depletion Allowance:** (Domestic and Foreign) 14% for chemical and metallurgical uses; 5% if used for riprap, ballast, road material, rubble, concrete aggregate, and similar purposes.

7. **Government Stockpile:** None.

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e/ Estimated. NA Not available.

1/ See also Stone (Dimension).

2/ Excludes office staff.

3/ Defined as imports - exports + adjustments for Government and industry stock changes; changes in stocks not available and assumed to be zero for apparent consumption and net import reliance calculations.

4/ See page 184 for definitions.

Prepared by Valentin V. Tepordei, telephone number (202) 634-1185.

8. Events, Trends, and Issues: Crushed stone output in 1987 increased 3%, compared with that of 1986. It is estimated that 1988 domestic production and U.S. apparent consumption will be about 1.05 billion tons each.

The crushed stone industry continued to be concerned with safety regulations and environmental restrictions. Shortages in some urban and industrialized areas were expected to continue to increase due to local zoning regulations and land development alternatives. This was expected to continue to cause a relocation of crushed stone quarries from high population centers.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production e/		Reserves and Reserve Base 4/
	1986	1987	
United States	1,023	1,051	Adequate except special types and local shortages.
Other Countries	NA	NA	

10. World Resources: Stone resources of the world are practically inexhaustible. High-purity limestone and dolomite suitable for chemical and metallurgical use are limited in many geographical areas. The largest resources of high-purity limestone and dolomite in the United States are in the central and eastern parts of the country.

11. Substitutes: Crushed stone substitutes for roadbuilding include sand and gravel and slag. Substitutes for aggregate include sand and gravel, slag, sintered or expanded clay or shale, and perlite or vermiculite.

STONE (DIMENSION) 1/

(Data in thousand short tons and million dollars, unless noted)

1. Domestic Production and Use: Dimension stone totaling 1.17 million tons valued at $181 million was produced by 200 companies at 300 quarries in 36 States. It was used in construction of buildings, 47%; and monuments, 26%; the remainder was used as rubble, 14%; curbing, 8%; flagging, 4%; and other, 1%. Leading producing States were Georgia, Indiana, and Vermont, which together accounted for about 40% of the output. Of the total, 55% was granite, 25% was limestone, 11% was sandstone, 4% was slate, 3% was marble, and 2% was other.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production: Tonnage	1,090	1,141	1,121	1,175	1,170
Value	148	162	172	173	181
Imports for consumption, value	192	223	291	380	425
Exports, value	19	23	14	15	16
Consumption, apparent, value	321	362	449	538	590
Price	Variable, depending on type of product				
Stocks, yearend	Not available				
Employment, quarry and mill 2/	3,000	3,000	3,000	3,000	3,000
Net import reliance 3/ as a percent of apparent consumption (based on value)	54	55	62	68	69
Granite only:					
Production	601	622	606	625	625
Imports for consumption	120	490	620	698	521
Exports	88	92	46	54	50
Consumption, apparent	648	1,020	1,180	1,269	1,096
Price	Variable, depending on type of product				
Stocks, yearend	Not available				
Employment, quarry and mill 2/	1,500	1,500	1,500	1,500	1,500
Net import reliance 3/ as a percent of apparent consumption (based on tonnage)	5	39	49	51	43

3. Recycling: Small amounts of dimension stone are recycled, principally by restorers of old stone work.

4. Import Sources (1983-86): (based on value) Dimension stone: Italy, 67%; Canada, 8%; Spain, 7%; Taiwan, 5%; other, 13%.
Granite only: Italy, 66%; Canada, 16%; Spain, 6%; other, 12%.

5. Tariff: Dimension stone tariffs varied from free to 7.5% ad valorem for most favored nations in 1987 according to type, size, value, and degree of preparation.

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e/ Estimated. NA Not available.
1/ See also Stone (Crushed).
2/ Excluding office staff.
3/ Defined as imports - exports + adjustments for Government and industry stock changes. Changes in stocks were assumed to be zero in the net import reliance and apparent consumption calculations, because data on stocks were not available.
4/ See page 184 for definitions.

Prepared by Harold A. Taylor, Jr., telephone number (202) 634-1180.

6. Depletion Allowance: (Domestic and Foreign) 14%; 5% if used for rubble and other nonbuilding purposes.

7. Government Stockpile: None.

8. Events, Trends, and Issues: Dimension stone imports increased significantly for the seventh successive year to a value of $425 million in 1987. Value of imports exceeded that of production for the fifth successive year.

9. World Mine Production and Reserve Base:

	Mine Production		Reserves and Reserve Base 4/
	1986	1987 e/	
United States	1,175	1,170	Adequate except for certain special types and local shortages.
Other countries	NA	NA	
World total	NA	NA	

10. World Resources: Dimension stone resources of the world are inexhaustible. Resources can be limited on a local level, or occasionally on a regional level, by the lack of a particular kind of stone or a lack of a given stone that is suitable for dimension purposes.

11. Substitutes: Substitutes for dimension stone include concrete, steel, aluminum, resin agglomerated stone, and plastics.

STRONTIUM

(Data in short tons of contained strontium 1/, unless noted)

1. **Domestic Production and Use:** No strontium minerals have been produced in the United States since 1959. Celestite, the most common strontium mineral consisting primarily of strontium sulfate, was imported almost exclusively from Mexico. A company in Georgia was the only major U.S. producer of strontium compounds. Primary strontium compounds were used in the manufacture of faceplate glass for color television picture tubes, 58%; pyrotechnics and signals, 15%; ferrite ceramic magnets, 7%; pigments and fillers, 7%; and other uses, 13%.

2. **Salient Statistics--United States:**

	1983	1984	1985	1986	1987 e/
Production, strontium minerals			None		
Imports for consumption:					
Strontium minerals	21,800	21,500	16,500	14,600	19,000
Strontium compounds	500	2,600	4,000	4,700	6,900
Exports 2/ (celestite and compounds)		Not available			
Shipments from Govt. stockpile excesses			None		
Consumption, apparent (celestite and compounds)	22,700	W	W	W	W
Price, average value of mineral imports at port of exportation, dollars per ton	74.42	87.87	88.43	96.78	88.00
Stocks, consumer, yearend (celestite only)	5,900	W	W	W	W
Net import reliance 3/ as a percent of apparent consumption	100	100	100	100	100

3. **Recycling:** None.

4. **Import Sources (1983-86):** Strontium minerals: Mexico, 96%; Spain, 4%. Strontium compounds: Federal Republic of Germany, 63%; Mexico, 11%; Spain, 10%; Italy, 6%; other, 10%. Decreased imports of strontium minerals were due to the closing of a major domestic strontium carbonate facility in 1984. The remaining carbonate producer began to make up for the lost domestic production resulting from this closing. Increased demand, inexpensive imports, and decreased domestic production accounted for significant increases in imports of strontium compounds since 1983.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Compounds:			
Carbonate:			
Not precipitated	421.70	Free	Free
Precipitated	421.72	4.2% ad val.	25% ad val.
Nitrate	421.74	4.2% ad val.	25% ad val.
Oxide	421.76	4.2% ad val.	25% ad val.
Minerals:			
Celestite	421.82	Free	Free
Other	421.84	3.7% ad val.	25% ad val.
Other	421.86	3.7% ad val.	25% ad val.

6. **Depletion Allowance:** 22% (Domestic), 14% (Foreign).

7. **Government Stockpile:**

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Celestite 1/	-	5,887	5,887	-

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ The strontium content of celestite is 43.88%, which was used to convert units of celestite.
2/ Export data are not available and are assumed to be zero for net import reliance and apparent consumption calculations.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ Short tons of strontium minerals.
5/ See page 184 for definitions.
6/ Excludes China and the U.S.S.R.

Prepared by Joyce A. Ober, telephone number (202) 634-1177.

8. Events, Trends, and Issues: Mexico continued as the main source of imported celestite, the primary feedstock for domestic production of strontium carbonate and other downstream strontium compounds. U.S. demand for products containing strontium was strong for the second consecutive year.

The growth of the television industry in the Far East prompted two separate Western European chemical companies, one French and one West German, to announce plans for construction of facilities to produce strontium carbonate and barium carbonate in the Republic of Korea for use in the manufacture of faceplate glass for color television picture tubes.

The first shipment of strontium carbonate was made from a newly completed Mexican strontium carbonate facility on May 1, 1987. Production from this plant, which is located in Torreon in Coahuila State, was sold primarily in Japan, the Republic of Korea, and Taiwan.

A high-grade celestite deposit was identified in the desert region of the South Australian Great Artesian Basin. Five areas of celestite surface mineralization containing 90.0% to 96.6% strontium sulfate have been found.

Strontium was identified by the U.S. Department of Defense as one of 22 "high-tech" metals and was one of the materials being investigated as a possible component of high-temperature superconductors.

An antidumping case was reviewed by the U.S. Department of Commerce concerning an allegation of dumping of strontium nitrate from Italy by one manufacturer/exporter from June 1, 1983, through May 14, 1984. Commerce determined that no dumping had occurred. The final results were effective June 1, 1987.

9. World Mine Production, Reserves, and Reserve Base: 4/

	Mine Production		Reserves 5/	Reserve Base 5/
	1986	1987 e/		
United States	-	-	-	1,500,000
Algeria	6,000	6,000		
Argentina	550	550		
Cyprus	6,000	6,000		
Iran	24,250	25,000		
Italy	5,144	5,200		
Madagascar	-	-	Other:	Other:
Mexico	35,300	35,600	7,500,000	11,700,000
Pakistan	1,200	1,200		
Spain	44,000	44,000		
Turkey	38,600	60,000		
United Kingdom	22,000	22,000		
China	NA	NA		
U.S.S.R.	NA	NA		
World Total (may be rounded)	6/ 183,044	6/ 206,000	7,500,000	13,200,000

10. World Resources: Resources in the United States are several times the reserve base. World resources, although not thoroughly evaluated, are believed to exceed 1 billion tons.

11. Substitutes: Although it is possible to substitute for strontium in some of its applications, to do so would adversely affect performance and/or cost. For example, barium could replace strontium in color television tube glass only after extensive circuit redesign to reduce operating voltages that produce harmful secondary x-rays. Barium replacement of strontium in ferrite ceramic permanent magnets would decrease the maximum energy and temperature characteristics of the magnet. Substituting for strontium in pyrotechnics would be impractical because the desired brilliance and visibility are imparted only by strontium and its compounds.

SULFUR

(Data in thousand metric tons of sulfur, unless noted)

1. Domestic Production and Use: In 1987, sulfur was produced at 178 operations in 32 States, Puerto Rico, and the U.S. Virgin Islands for a total shipment value of nearly $1.0 billion. Texas and Louisiana accounted for 51% of domestic production. Ten companies with 71 operations accounted for 74% of production. Frasch sulfur was produced by three companies operating four mines in Texas and Louisiana accounting for 31% of domestic production of sulfur in all forms. Recovered elemental sulfur was produced as a coproduct at petroleum refineries, natural gas processing plants, and coking plants in 26 States, Puerto Rico, and the U.S. Virgin Islands by 56 companies with 157 individual plants. Sulfur was also produced in the form of sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide in 11 States by 10 companies with 17 operations. Sulfur shipped for domestic consumption was obtained mainly from domestic sources: recovered, 48%; Frasch, 25%; and combined byproduct sulfuric acid, primary pyrites, hydrogen sulfide, and sulfur dioxide, 10%. The remaining 17% of the sulfur was obtained by importing Frasch and recovered sulfur. About 87% of the sulfur was converted to sulfuric acid prior to end use. Agricultural chemicals (fertilizers) accounted for 70% of sulfur demand. Chemicals, organic and inorganic, accounted for 11%, petroleum refining 7%, and metal mining 2%. Other uses, 10%, were widespread, as most products produced by industry require sulfur in one form or another during some stage of their manufacture.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production: Frasch	3,202	4,193	5,011	4,043	3,300
Recovered elemental	4,955	5,214	5,313	5,816	6,150
Other forms	1,133	1,245	1,285	1,228	1,150
Total	9,290	10,652	11,609	11,087	10,600
Shipments, all forms	10,285	11,456	11,229	11,134	10,800
Imports for consumption, Frasch and recovered	1,695	2,557	2,104	1,347	1,900
Exports, Frasch and recovered	992	1,334	1,365	1,895	1,400
Consumption, apparent, all forms	10,988	12,679	11,968	10,586	11,300
Price, reported average value, dollars per ton of elemental sulfur, f.o.b. mine/plant	87.24	94.31	106.46	105.22	91.00
Stocks, producer, yearend	3,223	2,419	2,799	2,748	2,550
Employment, mine/plant e/	3,700	3,500	3,400	3,200	3,250
Net import reliance 1/ as a percent of apparent consumption	15	16	3	E	6

3. Recycling: About 900,000 tons, sulfur content, of spent acid was reclaimed from petroleum refining and chemical processes.

4. Import Sources (1983-86): Canada, 63%; Mexico, 36%; other, 1%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Sulfur (crude)	415.4500	Free	Free

6. Depletion Allowance: 22% (Domestic), 22% (Foreign).

7. Government Stockpile: None.

e/ Estimated. E Net exporter.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ See page 184 for definitions.

Prepared by David E. Morse, telephone number (202) 634-1190.

8. Events, Trends, and Issues: International trade in sulfur decreased for the third consecutive year; international prices continued the decline that began in the fourth quarter of 1985; and total world demand increased only marginally from that of 1986. World demand, however, continued to surpass production, requiring a drawdown from stocks, principally in Canada which remained the world's foremost sulfur exporting nation. Nearly two-thirds of the elemental sulfur produced in the world on an annual basis is produced as a byproduct of petroleum refining or natural gas processing so that the quantity of sulfur supplied from these sources is dependent on the demand for fuels, not on the demand for sulfur.

Production from U.S. Frasch mines, the major world source of discretionary sulfur, decreased substantially because reduced international prices restricted export opportunities. Production from petroleum refineries exceeded 3.5 million tons for the second consecutive year; output from natural gas increased substantially, reflecting a full year of operation of a large-scale facility in Wyoming. The domestic fertilizer industry, which accounts for over two-thirds of the U.S. sulfur demand, supplied not only the U.S. farmer but also world markets. Domestic sulfur demand increased because of increased exports of U.S.-produced fertilizers. It is estimated that in 1988 domestic sulfur production will be 10.8 million tons and U.S. apparent consumption will be 11.5 million tons. If the U.S. fertilizer manufacturers and farmers, however, are not able to compete successfully in the international marketplace, domestic demand for sulfur will decline.

9. World Mine Production, Reserves, and Reserve Base:

	Production - All Forms		Reserves 2/	Reserve Base 2/
	1986	1987 e/		
United States	11,087	10,600	152,000	175,000
Canada	6,516	6,750	150,000	300,000
France	1,306	1,200	11,000	20,000
Germany, Federal Republic of	1,575	1,650	20,000	30,000
Italy	494	500	10,000	15,000
Japan	2,361	2,300	5,000	10,000
Mexico	2,165	2,300	80,000	100,000
Spain	1,310	1,000	20,000	30,000
Near East	2,563	2,800	210,000	500,000
Other Market Economy Countries	5,284	5,200	98,000	300,000
Centrally Planned Economies	19,500	20,200	550,000	1,250,000
World Total (may be rounded)	54,161	54,500	1,300,000	2,730,000

10. World Resources: Resources of elemental sulfur in evaporite and volcanic deposits and sulfur associated with natural gas, petroleum, tar sands, and metal sulfides amount to about 5 billion tons. The sulfur in gypsum and anhydrite is almost limitless and some 600 billion tons are contained in coal, oil shale, and shale rich in organic matter, but low-cost methods have not been developed to recover sulfur from these sources. The domestic resource is about one-fifth of the world total.

11. Substitutes: There are no adequate substitutes for sulfur at present or anticipated price levels; some acids, in certain applications, may be substituted for sulfuric acid.

TALC AND PYROPHYLLITE

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: The total estimated value of 1987 domestic production was $24 million. There were 27 talc producing mines in 9 States in 1987. Companies in Montana, New York, Texas, and Vermont accounted for 95% of domestic production. Ground talc was consumed in ceramics, 35%; paints, 17%; paper, 13%; roofing, 11%; plastics, 7%; cosmetics, 5%; and other, 12%. Four firms in California and North Carolina accounted for 100% of domestic pyrophyllite production. Pyrophyllite production increased in 1987. Consumption was in ceramics, 55%; refractories, 17%; insecticides, 11%; and other, 17%.

2. Salient Statistics—United States:

Salient Statistics—United States:	1983	1984	1985	1986	1987 e/
Production, mine	1,066	1,127	1,269	1,302	1,235
Sold by producers	1,163	1,198	1,148	1,153	1,079
Imports for consumption	44	45	47	52	54
Exports	218	256	237	234	298
Shipments from Govt. stockpile excesses			None		
Consumption, apparent	989	1,009	1,079	1,120	982
Price, crude or ground, dollars per ton	21-280	20-260	19-300	25-350	25-350
Stocks, producer, yearend	294	201	201	201	210
Employment, mine and mill	800	800	800	850	900
Net import reliance 1/ as a percent of apparent consumption			Net exporter		

3. Recycling: Insignificant.

4. Import Sources (1983-86): Canada, 60%; Italy, 12%; France, 7%; Republic of Korea, 4%; other, 17%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude, not ground	523.31	0.02¢/lb	0.25¢/lb
Ground, washed, powdered	523.33	2.4% ad val.	35.0% ad val.
Cut or sawed	523.35	Free	1¢/lb
Other, n.s.p.f.	523.37	4.8% ad val.	35.0% ad val.

6. Depletion Allowance: Block steatite talc—22% (Domestic), 14% (Foreign).
Other—14% (Domestic), 14% (Foreign).

7. Government Stockpile:

Stockpile Status—9-30-87
(Short tons)

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Talc, block and lump	28	1,081	63	-
Talc, ground	-	1,089	-	-

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e/ Estimated. n.s.p.f. not specifically provided for.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ See page 184 for definitions.

Prepared by Robert L. Virta, telephone number (202) 634-1206.

8. **Events, Trends, and Issues:** U.S. mine production of talc and pyrophyllite decreased 5% from that of 1986 and U.S. apparent consumption decreased 12% from that of 1986. Imports for consumption increased 4% and U.S. exports increased 27% from those of 1986.

On April 30, the Occupational Safety and Health Administration (OSHA) extended a partial stay of ruling 29CFR 1910.1001 which regulates occupational exposure to asbestos and the nonasbestiform varieties of tremolite, actinolite, and anthophyllite, while it continued to evaluate the economic impact of the ruling on the mining and construction industries. The 2 fibers per cubic centimeter exposure limit that was established by the 1972 asbestos exposure standard will remain in effect until July 21, 1988 with respect to nonasbestiform actinolite, anthophyllite, and tremolite. The Environmental Protection Agency reviewed the national emission standards for hazardous air pollutants and began surveying producers of 9 commodities, including talc, to determine the asbestos content and the total mineral fiber content of mine emissions.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production		Reserves 2/	Reserve Base 2/
	1986	1987 e/		
United States	1,302	1,235	150,000	600,000
Brazil	469	661	15,000	60,000
India	419	441	4,000	10,000
Japan	1,471	1,385	145,000	220,000
Korea, Republic of	992	990	15,000	20,000
Other Market Economy Countries	1,931	1,970	40,000	150,000
Centrally Planned Economies	1,945	1,980	45,000	180,000
World Total	8,529	8,662	414,000	1,240,000

10. **World Resources:** The United States is self-sufficient in most grades of talc and related minerals. Domestic and world resources are estimated to be approximately five times the quantity of reserves.

11. **Substitutes:** In the ceramics market, talc and pyrophyllite compete with each other as well as kaolin, fuller's earth, other inorganic fillers, and feldspar. Phosphate-bonded talc is a thoroughly acceptable substitute for block steatite talc; potential alternative materials are talc bonded with magnesium oxychloride, and either phosphate-bonded or hot-pressed synthetic mica. Talc, mica, and other minerals compete for plastic (especially polypropylene) filling and reinforcing roles.

TANTALUM

(Data in thousand pounds of tantalum content, unless noted)

1. **Domestic Production and Use**: There has been no significant tantalum mining industry since 1959, the exception being small unreported quantities of tantalum-bearing concentrates produced in 1980-82. Most metal, alloys, and compounds were produced by five companies with six plants; tantalum units were obtained from imported concentrates and tin slags, and from both foreign and domestic scrap. Total estimated value of domestic shipments of metal, alloys, and compounds was about $130 million. Consumption in the form of metal, powder, ingot, fabricated forms, and compounds and alloys had the following end uses: electronic components, 59%; machinery, 19%; transportation, 15%; and other, 7%.

2. **Salient Statistics--United States**:

	1983	1984	1985	1986	1987 e/
Production, mine			None		
Imports for consumption, concentrate, tin slags, and other 1/	W	W	W	W	W
Exports, concentrate, metal, alloys, waste, and scrap e/	262	383	320	312	300
Shipments from Govt. stockpile excesses	-	-	2/(254)	-	-
Consumption: Reported, raw material e/	900	1,300	1,100	W	NA
Apparent	1,181	1,680	800	820	900
Price, tantalite, dollars per pound 3/	25.06	30.66	27.58	19.44	22.00
Stocks, industry, processor, yearend	W	W	W	W	W
Employment, processor e/	500	500	500	450	450
Net import reliance 4/ as a percent of apparent consumption	97	92	89	91	92

3. **Recycling**: Combined prompt industrial and obsolete scrap consumed was less than 10% of raw materials consumed. Generation of new scrap was estimated to be less than 400,000 pounds, most of which was consumed by processors.

4. **Import Sources (1983-86)**: Thailand, 33%; Brazil, 10%; Australia, 7%; Canada, 4%; other, 46%.

5. **Tariff**:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Potassium fluotantalate	420.3620	3.1% ad val.	25.0% ad val.
Tantalum concentrate	601.4200	Free	Free
Synthetic tantalum/columbium concentrate	603.6700	Free	30.0% ad val.
Tantalum, unwrought:			
Waste and scrap	629.0520	3.7% ad val.	25.0% ad val.
Metal	629.0540	3.7% ad val.	25.0% ad val.
Alloys	629.0700	4.9% ad val.	25.0% ad val.
Tantalum, wrought	629.1000	5.5% ad val.	45.0% ad val.

6. **Depletion Allowance**: 22% (Domestic), 14% (Foreign).

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Metal, alloys, and synthetic concentrates; exclusive of waste and scrap.
2/ Data in parentheses denote stockpile acquisitions.
3/ Average value, contained tantalum pentoxide, 60% basis.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ Excludes production of tantalum contained in tin slags reported by Tantalum-Niobium International Study Center (TIC) as 622,000 pounds in 1986; data not available for 1987.
6/ See page 184 for definitions.
7/ Excludes Centrally Planned Economies.

Prepared by Larry D. Cunningham, telephone number (202) 634-1029.

7. Government Stockpile: In addition to quantities shown below, the stockpile contains a negligible quantity in nonstockpile-grade metal and 1,152,000 pounds in nonstockpile-grade minerals.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Carbide powder	-	29	-	-
Metal	-	201	-	-
Minerals	8,400	1,686	-	-

8. Events, Trends, and Issues: Demand for tantalum in 1987 increased by about 10%, and the tantalum market showed signs of recovering from the significant downturn that started in 1985. Estimated factory sales of tantalum capacitors, and overall tantalum shipments were both up substantially from the 1986 levels. However, imports for consumption of tantalum feed materials were virtually unchanged, reflecting the continued drawdown of processor inventory stocks. The published spot price for tantalum concentrates, which began the year at about $21 per pound of contained pentoxide, was being quoted in the fourth quarter at around $23 per pound. Published prices for tantalum mill products and powders, quoted in the range of $100 to $160 per pound throughout the first quarter, were suspended in mid-April. It is estimated that in 1988 domestic mine production of tantalum will be zero and U.S. apparent consumption will be less than 1 million pounds.

There are no known uncontrollable health hazards connected with production or fabrication of tantalum metals and compounds. Fumes, gases, dust, and low-level radiation generated by extraction plants can be controlled by modern technology.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production e/5/		Reserves 6/	Reserve Base 6/
	1986	1987		
United States	-	-	-	Negligible
Australia	70	90	10,000	20,000
Brazil	116	130	2,000	3,000
Canada	-	-	4,000	5,000
Malaysia	12	10	2,000	4,000
Nigeria	2	10	7,000	10,000
Thailand	73	100	16,000	20,000
Zaire	75	80	4,000	10,000
Other Market Economy Countries	46	60	3,000	4,000
Centrally Planned Economies	NA	NA	NA	NA
World Total 7/	394	480	48,000	76,000

10. World Resources: Most of the world's resources of tantalum occur outside the United States. On a worldwide basis, identified resources of tantalum are considered adequate to meet projected needs. These resources are largely located in Australia, Brazil, Canada, Egypt, Malaysia, Nigeria, Thailand, and Zaire. The United States has about 3.4 million pounds of tantalum resources located in identified deposits, which were considered uneconomic at 1987 prices.

11. Substitutes: The following materials can be substituted for tantalum, but usually with less effectiveness: Columbium in superalloys and carbides; aluminum and ceramics in electronic capacitors; glass, titanium, zirconium, columbium, and platinum in corrosion-resistant equipment; and tungsten, rhenium, molybdenum, iridium, hafnium, and columbium in high-temperature applications.

TELLURIUM

(Data in metric tons of tellurium content, unless noted)

1. Domestic Production and Use: Commercial-grade tellurium was recovered by one domestic copper refiner from copper anode slimes generated in the electrolytic refining of copper. High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide. Tellurium's primary use was as an alloying agent in the production of free-machining steels. It was also used as a minor additive in copper and lead alloys and malleable cast iron, as an accelerator in rubber compounding, and as a semiconductor in thermoelectric, thermal imaging, and photoelectric applications. Consumption by major use was estimated as follows: iron and steel products, 60%; nonferrous metals, 25%; chemicals, 10%; and other, 5%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, refinery	W	W	W	W	W
Imports for consumption	12	35	30	14	30
Exports		Not available			
Consumption, apparent	57	107	W	W	W
Price, dollars per pound, 99.7% min. 1/	9.00	11.00-11.50	11.00-11.50	10.00	14.00
Stocks, producer, refined, yearend	W	W	W	W	W
Employment		Not available			
Net import reliance 2/ as a percent of apparent consumption	W	W	W	W	W

3. Recycling: Insignificant.

4. Import Sources (1983-86): Canada, 52%; United Kingdom, 18%; Philippines, 8%; Japan, 3%; other, 19%.

5. Tariff:

Tariff:	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Metals	632.48	Free	25.0% ad val.
Compounds	421.90	3.7% ad val.	25.0% ad val.

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Yearend prices quoted by the sole producer.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.
4/ Excludes production in the United States, Other Market Economy Countries, and Centrally Planned Economies.
5/ Excludes Centrally Planned Economies.

Prepared by Neldon L. Jensen, telephone number (202) 634-1058.

8. Events, Trends, and Issues: U.S. production of tellurium in 1987 was at essentially the same level as in 1986. Imports increased about twofold; consumption increased also, but by a lesser amount. The one domestic producer's quoted price was $14.00 per pound for commercial-grade metal. A quantitatively minor, but important, use for tellurium has emerged in defense and space electronics, where mercury-cadmium-tellurium has become one of the most important semiconductors--it is the principal photoconductive material used in infrared imaging systems.

9. World Refinery Production, Reserves, and Reserve Base:

	Refinery Production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States	W	W	3,700	6,000
Canada	16	20	980	2,000
Japan	60	60	-	-
Peru	10	15	780	2,000
Other Market Economy Countries	NA	NA	16,540	22,000
Centrally Planned Economies	NA	NA	NA	6,000
World Total	4/ 86	4/ 95	5/ 22,000	38,000

10. World Resources: In addition to the above large reserve base of byproduct tellurium contained in identified copper deposits of economic grade, several other sources of byproduct metal exist. The reserve base of lead ore contains about one-fourth the quantity of tellurium occurring in economic copper deposits; however, at present very little lead is refined by the electrolytic method, which allows tellurium recovery. Relatively small quantities of tellurium can be recovered from gold telluride ores. Resources of copper and other metals that are undeveloped, of uneconomic grade, or as yet undiscovered, contain several times the quantity of tellurium in identified economic copper deposits. Although coal deposits contain an estimated average of 0.015 part per million tellurium, or a total content about four times that of economic copper deposits, recovery of tellurium from coal appears unlikely in the foreseeable future.

11. Substitutes: The chief materials which can substitute for tellurium include selenium, bismuth, and lead in metallurgical applications, selenium and sulfur in rubber compounding applications, and selenium and germanium in electronic applications.

THALLIUM

(Data in pounds of thallium content, unless noted)

1. Domestic Production and Use: Thallium is a byproduct recovered from flue dusts and residues collected in the smelting of copper, zinc, and lead ores. Although thallium was contained in ores mined in the United States, thallium metal was not recovered domestically in 1987. It was marketed as thallium compounds, or as metal in the form of sticks, ingots, or wire. The electronics industry consumed about 60% to 70% of the thallium used in 1987. The balance was used principally in pharmaceuticals, alloys, and glass manufacturing.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, refinery	-	-	-	-	-
Imports for consumption 1/	2,799	2,535	2,301	4,450	4,500
Exports		Not	available		
Consumption e/	2,800	2,500	2,300	4,000	4,000
Price, metal, dollars per pound 2/	35-45	35	20	30	20
Stocks, producer, yearend	W	W	W	W	W
Employment e/	-	-	-	-	-
Net import reliance 3/ as a percent of apparent consumption	100	100	100	100	100

3. Recycling: Insignificant.

4. Import Sources (1983-86): Belgium-Luxembourg, 54%; the Netherlands, 16%; Federal Republic of Germany, 14%; United Kingdom, 6%; other, 10%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Unwrought metal and waste and scrap	632.50	Free	25% ad val.
Compounds	422.00	3.7% ad val.	25% ad val.

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Includes thallium contained in compounds.
2/ In 1983-85, estimated price of imported metal, 99.99% pure. In 1986-87 estimated price based on value of reported metal.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.
4/ Based on the estimated thallium content of zinc ores.
5/ See page 184 for definitions.

Prepared by Thomas O. Llewellyn, telephone number (202) 634-1083.

8. Events, Trends, and Issues: As a result of the discontinuance of domestic refinery production of thallium, the United States met its domestic requirements from imports and withdrawals from stocks.

Thallium is a toxic material and is controlled to prevent a threat to the environment or labor force.

9. World Mine Production, Reserves, and Reserve Base: 4/

	Mine Production		Reserves 5/	Reserve Base 5/
	1986	1987 e/		
United States	1,000	1,000	70,000	260,000
Other Countries	31,000	31,000	760,000	1,160,000
World Total	32,000	32,000	830,000	1,420,000

10. World Resources: World resources of thallium contained in zinc resources are about 38 million pounds, most of which are in Europe, Canada, and the United States. An additional 1.4 billion pounds are contained in the world's identified resources of coal.

11. Substitutes: While other light-sensitive materials can be substituted for thallium and its compounds in specific electronic applications, ample supplies of thallium discourage development of substitute and alternate materials.

THORIUM 1/

(Data in metric tons of thorium oxide (ThO_2) equivalent, unless noted)

1. Domestic Production and Use: In 1987, thorium was recovered as a byproduct of processing monazite, a rare earth-thorium phosphate mineral, valued primarily for its rare-earth content. Thorium-bearing monazite was mined in Florida by one company as a byproduct of processing heavy mineral sands for titanium and zirconium minerals. Thorium products used and produced by the domestic industry came from imports and industry and Government stocks. Domestic rare-earth processing plants in Tennessee and Texas produced, respectively, thorium oxide and thorium nitrate from imported rare-earth concentrates and compounds. About 18 companies processed or fabricated thorium into various forms, including nuclear fuel. Thorium was used as a metal, oxide, nitrate, carbide, and chloride. Nonenergy uses were in incandescent lamp mantles, magnesium-thorium alloys, refractories, ceramics, welding electrodes, and other uses. Thorium was also used as a nuclear fuel at a commercial electric generating plant at Fort St. Vrain, CO.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, refinery 2/	Not available				
Imports, metal, alloys and compounds e/3/	46	45	69	20	35
Exports, metals, waste, and scrap e/	1	1	2	17	17
Shipments from Govt. stockpile excesses	-	-	2	-	-
Consumption, reported e/	47	51	74	40	57
Price, yearend, dollars per kilogram, ThO_2:					
Nitrate, mantle-grade	10.60	10.10	10.10	13.60	10.10
Oxide, 99% grade	31.00	35.85	35.85	38.00	41.00
Stocks, industrial, yearend	Not available				
Employment, mine	None				
Net import reliance 4/ as a percent of apparent consumption	Not available				

3. Recycling: None.

4. Import Sources (1983-86): Refined Products: France, 74%; United Kingdom, 13%; Netherlands, 7%; Canada, 3%; other, 3%.
Monazite: Australia, 96%; other, 4%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore	601.45	Free	Free
Nitrate and oxide	422.10 & 422.12	7.8% ad val.	35.0% ad val.
Unwrought metal, waste and scrap	632.52	4.2% ad val.	25.0% ad val.
Alloys	632.68	3.0% ad val.	25.0% ad val.

6. Depletion Allowance: Monazite, 22% on thorium content, 14% on rare earth and yttrium content (Domestic); 14% (Foreign).

e/ Estimated. NA Not available.
1/ See also Rare-Earth Metals and Yttrium.
2/ All domestically consumed thorium was derived from imported materials.
3/ Includes estimated ThO_2 equivalents in imported gas mantles, thorium nitrate, thorium oxide, and other thorium compounds and metal. Monazite containing 200 to 550 tons of thorium oxide has been imported annually for its rare earth content, but until 1985, was not used to produce thorium products.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ Thorium oxide equivalent.
6/ See page 184 for definitions.

Prepared by James B. Hedrick, telephone number (202) 634-1058.

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Thorium nitrate 5/	130	1,545	11	-

8. Events, Trends, and Issues: Demand for thorium is expected to remain about level through 1990. Beyond 1990 the growth rate is forecast to decline as nonradioactive substitutes are developed and environmental issues relating to the handling, storage, and disposal of thorium impede future commercial development. The quantity of thorium consumed for nuclear power generation has been small when compared with uranium and fossil fuels, and is not expected to increase in the United States. It is estimated that in 1988 U.S. consumption will be met entirely from imports and existing industry and Government stocks.

The principal environmental concern in mining monazite-bearing placers along beaches and rivers was the possible conflict with urban and recreational land uses and damage to undeveloped areas. Such concerns have limited the availability of minable deposits. Public concern and foreign and domestic regulations on handling and storing radioactive thorium materials have limited their use. State and Government regulations along with public concerns over the safe storage of thorium-bearing residues have been costly to the domestic industry. Mine reclamation was successful at heavy mineral sands operations in Australia and the United States, and in some instances has transformed unproductive land into recreational and agricultural areas. Reserve data, given below, have been revised for all countries except Malaysia, Norway, and "Other Market Economy Countries", as a result of updated information.

9. World Refinery Production, Reserves, and Reserve Base:

	Refinery Production		Reserves 6/	Reserve Base 6/
	1986	1987 e/		
United States	NA	NA	158,000	298,000
Australia	NA	NA	44,000	49,000
Brazil	NA	NA	16,000	18,000
Canada	NA	NA	100,000	100,000
France	NA	NA	-	-
India	NA	NA	292,000	300,000
Malaysia	NA	NA	4,500	4,500
Norway	NA	NA	166,000	183,000
South Africa, Republic of	NA	NA	35,000	39,000
Other Market Economy Countries	NA	NA	72,000	46,000
Centrally Planned Economies	NA	NA	45,000	50,000
World Total (rounded)	NA	NA	930,000	1,100,000

10. World Resources: Large deposits of thorium occur in the United States in beach and stream placers, veins, and carbonatites. In these deposits there are thorium resources of more than 500,000 tons of ThO_2. Disseminated deposits in various other alkaline igneous rocks contain additional resources of more than 2 million tons of ThO_2. Large thorium resources are also found in Canada, India, Greenland, Brazil, the Republic of South Africa, and Australia.

11. Substitutes: Satisfactory alternative materials are not available for the major nonenergy uses of thorium, although research to develop non-radioactive substitutes was reported. In energy applications, uranium could be substituted as a nuclear fuel for the thorium 232/uranium 233 fuel system. Uranium, is in fact, the principal fuel used in nuclear power generation.

TIN

(Data in metric tons of tin content, unless noted)

1. **Domestic Production and Use:** In 1987 small quantities of tin concentrates were produced from placer deposits in Alaska. The only U.S. tin smelter, at Texas City, TX, produced about 3,000 tons of tin from imported and domestic tin concentrates, residues, and other secondary tin-bearing materials. About one-fourth of the tin consumed in the United States was derived from secondary material at 4 detinning plants and 171 secondary nonferrous metal processing plants located principally in the East. Twenty-five firms consumed about 66% of the primary tin. The major uses were in electrical, 20%; cans and containers, 17%; construction, 16%; transportation, 14%; and other, 33%. The estimated value of consumption in 1987 was $212 million based on the New York composite price.

2. **Salient Statistics--United States:**

	1983	1984	1985	1986	1987 e/
Production: Mine		Negligible			
Smelter e/	2,500	4,000	3,000	3,213	3,000
Secondary (old scrap)	10,766	11,141	10,037	10,191	11,000
Imports for consumption: Metal	34,048	41,224	33,830	35,768	34,000
Ore	969	3,272	1,616	3,936	3,000
Exports, ingots, pigs, and bars 1/	1,340	1,429	1,478	1,547	1,500
Shipments from Govt. stockpile excesses	2,865	2,397	3,005	5,490	3,500
Consumption, reported: Primary	34,301	37,819	37,187	32,548	34,000
Secondary	11,246	11,622	12,580	10,975	11,000
Consumption, apparent	49,231	57,215	45,750	51,535	51,900
Price, average, cents per pound:					
New York market	601	568	526	294	315
New York composite	655	624	596	370	418
London 2/	589	557	556	NA	NA
Kuala Lumpur 3/	591	565	541	272	303
Stocks, consumer and dealer, yearend	9,859	9,901	12,361	13,940	12,000
Employment, mine and primary smelter e/	200	200	150	100	80
Net import reliance 4/ as a percent of apparent consumption	73	74	72	74	73

3. **Recycling:** About 14,000 tons of old and new tin scrap, including tin alloys, was recycled in 1987.

4. **Import Sources (1983-86):** Brazil, 24%; Thailand, 17%; Indonesia, 13%; Bolivia, 12%; other, 34%.

5. **Tariff:**

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrate	601.48	Free	Free
Metal	622.02	Free	Free
Waste and scrap	622.10	Free	Free

6. **Depletion Allowance:** 22% (Domestic), 14% (Foreign).

7. **Government Stockpile:**

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Pig tin	42,674	177,053	11,789	3,100

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e/ Estimated. NA Not available.
1/ Excludes reexports.
2/ Tin was suspended from London Metal Exchange trading in October 1985 and was not traded in 1986 or 1987.
3/ The Kuala Lumpur market replaced the Penang market as the reference price in 1985.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ See page 184 for definitions.
6/ Excludes U.S. production.

Prepared by James F. Carlin, Jr., telephone number (202) 634-1073.

8. Events, Trends, and Issues: The reported consumption of primary tin remained about the same as that of 1986. It is estimated that in 1988, U.S. reported consumption of primary tin may be about 36,000 tons.

The year 1987 was one of stabilization and adjustment for world tin markets. Tin trading remained suspended from the London Metal Exchange (LME). Tin mine closures and production cutbacks continued throughout the world. Some LME trading firms and banks which had loaned funds to the International Tin Council (ITC) for earlier tin price support purchases continued litigation against the LME and the ITC and its member governments to recover losses. Tin prices remained at a level that was historically low and at which many of the world's tin mines could not operate profitably. Some mines were kept operating by Government financial support, while others cut back production, and some closed.

Tin prices were level throughout the year. The worldwide excess of supply relative to demand was estimated to decline to about 50,000 tons owing to mine closures and firming demand. The ITC continued to operate but had no substantive influence.

During the year the General Services Administration (GSA) sold no tin directly, but continued to award two metal processing firms with tin in payment for upgrading certain ores to ferroalloys for the GSA stockpile. This program was scheduled to be extended through 1988.

Tin was mined and smelted in small quantities in the United States and environmental effects were almost nonexistent. In secondary detinning operations, tin-containing muds are generated as waste material. Waste water from the rinsing of detinned steel may contain small amounts of caustic soda, sodium nitrate and tin. Drosses and dusts from industrial centers eventually become sources of secondary tin.

Concern grew over the toxic effects of tributyltin (TBT) antifoulant marine paints on aquatic life forms. Several coastal and Great Lakes states considered or passed legislation limiting the leaching of TBT compounds into the water. On October 1, 1987, the Environmental Protection Agency published a proposed regulation in the Federal Register, with an end of comment period of January 5, 1988, that would restrict the use of antifoulant marine TBT paints in various ways.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 5/	Reserve Base 5/
	1986	1987 e/		
United States	Negligible	Negligible	20,000	40,000
Australia	9,000	6,000	250,000	250,000
Bolivia	12,000	9,000	140,000	140,000
Brazil	27,000	29,000	650,000	650,000
Burma	1,500	1,500	20,000	20,000
Canada	2,500	2,000	60,000	60,000
Indonesia	22,000	18,000	680,000	680,000
Malaysia	28,000	26,000	1,110,000	1,110,000
Nigeria	1,100	1,000	20,000	20,000
Thailand	17,000	16,000	270,000	270,000
United Kingdom	4,600	3,000	90,000	90,000
Zaire	2,800	2,500	20,000	20,000
Other Market Economy Countries	11,000	8,000	200,000	200,000
China	15,000	15,000	400,000	400,000
U.S.S.R.	24,000	23,000	300,000	300,000
Other Centrally Planned Economies	3,000	3,000	30,000	30,000
World Total (may be rounded)	6/181,000	6/163,000	4,260,000	4,280,000

10. World Resources: U.S. tin resources, located primarily in Alaska, are insignificant when compared with those of the rest of the world. World resources are located principally in southeastern Asia, Australia, Bolivia, Brazil, China, and the U.S.S.R. Sufficient resources are available to sustain present production rates well into the next century.

11. Substitutes: Aluminum, glass, paper, plastic, or tin-free steel substitute for tin in cans and containers; epoxy resins for solder; aluminum alloys, copper-base alloys, or plastics for bronze; lead-base bearing alloys or plastics for tin-containing bearing metals, and sodium for some tin chemicals.

TITANIUM AND TITANIUM DIOXIDE 1/
(Data in short tons, unless noted)

1. Domestic Production and Use: Titanium sponge metal was produced by four firms, with production in Nevada, Ohio, Oregon, and Washington. Ingot was made by three sponge makers and by seven other firms located in seven States. Twenty-six companies produced titanium mill products or castings, mainly in the east-central region. In 1987, about 75% of the titanium metal was used in jet engines, airframes, and space and missile applications, and about 25% was used in the chemical processing industry, power generation, marine and ordnance, medical, and other nonaerospace applications. The value of sponge metal consumed was about $160 million, assuming an average selling price of about $4.00 per pound.

   Titanium dioxide (TiO_2) pigment, valued at about $1.5 billion, was produced by 5 companies at 11 plants in 8 States. In 1987, uses of TiO_2 were in paints, varnishes, and lacquers, 53%; paper, 21%; plastics, 16%; rubber, 2%; ceramics, 2%; and other 6%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Metal:					
Production	13,966	24,326	23,257	17,402	19,500
Imports for consumption, sponge	1,199	2,667	1,717	1,626	1,000
Exports, mainly scrap	7,830	7,333	10,387	9,930	10,500
Shipments from Govt. stockpile excesses 2/	-	(139)	(4,361)	-	-
Consumption of sponge metal, reported e/	16,072	24,713	21,606	19,489	20,000
Price, sponge, reported sales, dollars per pound, yearend	3.60	4.00	3.75	4.00	4.20
Stocks, sponge, industry, yearend e/	3,136	3,147	4,755	3,180	2,500
Employment, reduction plants e/	1,200	1,200	1,100	900	800
Net import reliance 3/ sponge only as a percent of apparent consumption	9	9	E	15	8
Titanium Dioxide:					
Production	760,385	834,889	860,443	917,305	950,000
Imports for consumption	174,857	193,501	196,213	202,674	192,000
Exports	91,702	106,124	101,954	112,227	118,000
Consumption, apparent	853,008	916,198	981,479	987,612	1,050,000
Price, rutile, list, dollars per pound, yearend	0.75	0.75	0.78	0.81	0.81
Stocks, producer, yearend	77,465	83,533	56,756	76,896	51,000
Employment e/	4,200	4,400	4,400	4,400	4,400
Net import reliance 3/ as a percent of apparent consumption	11	9	12	7	10

3. Recycling: New scrap metal recycled was 19,000 tons in 1987. In addition, estimated use of titanium in scrap, and in ferrotitanium made from scrap, by the steel industry was 2,800 tons; by the aluminum industry, 450 tons; and in miscellaneous alloying uses, 50 tons. Old scrap reclaimed was about 200 to 400 tons. There was no known recycling of TiO_2.

4. Import Sources (1983-86): Sponge metal: Japan, 95%; U.S.S.R., 3%; other, 2%. Titanium dioxide pigment: Federal Republic of Germany, 21%; France, 20%; Canada, 13%; United Kingdom, 11%; other, 35%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Waste and scrap metal	629.12	7.2% ad val.	25.0% ad val.
Unwrought metal	629.14	15.0% ad val.	25.0% ad val.
Wrought metal	629.20	15.0% ad val.	45.0% ad val.
Titanium dioxide	473.70	6.0% ad val.	30.0% ad val.

6. Depletion Allowance: Not applicable.

e/ Estimated. E Net exports. W Withheld to avoid disclosing company proprietary data.
1/ See also Ilmenite and Rutile.
2/ Figures in parentheses are acquisitions recorded as inventory.
3/ Defined as imports - exports + adjustments for Government and industry stock changes.

Prepared by Langtry E. Lynd, telephone number (202) 634-1073.

7. Government Stockpile: In addition to the quantities shown below, the stockpile contains 10,866 tons of nonstockpile-grade sponge metal.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Titanium sponge metal	195,000	25,965	-	-

8. Events, Trends, and Issues: Early in 1987, continued slack demand for titanium led to closure of a 2,500-ton-per-year titanium sponge plant at Moses Lake, WA, and a forging plant in South Gate, CA. The domestic titanium sponge production rate increased later in 1987, and was about 75% of capacity at yearend. Titanium demand improved mainly because of increases in new orders for commercial aircraft. Nonaerospace industrial demand improved slightly.

Talks were in progress directed toward purchase of an 80% share in an integrated titanium producer in Albany, OR, by its employees through an Employee Stock Ownership Plan. Plans for construction in 1987 of a 5,000-ton-per-year plant to produce titanium sponge from ilmenite, by a process involving fluoridation, and reduction with an aluminum-zinc alloy, were postponed indefinitely because of financing difficulties.

Titanium dioxide pigment plants continued to run near full capacity because of record-high U.S. and world TiO_2 pigment demand. The largest TiO_2 producer was still planning to build new plants in Brazil, the Republic of Korea, and Taiwan. In the last quarter of 1987, a former U.S. TiO_2 producer started up a new 42,000-ton-per-year plant in Canada. All of these new plants were to use the chloride pigment process.

It is estimated that in 1988 U.S. production of titanium sponge will be 21,000 tons, apparent consumption of sponge will be 22,000 tons, production of TiO_2 pigment will be 970,000 tons, and apparent consumption of pigment will be 1,070,000 tons.

9. Sponge Metal Production and Sponge and Pigment Capacity:

	Sponge Production		Capacity 1987	
	1986	1987 e/	Sponge	Pigment
United States	17,402	19,500	28,000	960,000
Canada	-	-	-	118,000
Finland	-	-	-	88,000
France	-	-	-	182,000
Germany, Federal Republic of	-	-	-	353,000
Japan	15,935	11,000	34,800	250,000
United Kingdom	e/1,500	1,500	5,500	281,000
Other Market Economy Countries	-	-	-	513,000
China e/	2,000	2,000	3,000	22,000
U.S.S.R. e/	48,000	49,000	55,000	137,000
Other Centrally Planned Economies e/	-	-	-	84,000
World Total (may be rounded)	85,000	83,000	126,000	2,988,000

10. World Resources: The source of titanium for domestic sponge production was almost entirely rutile. The sources for pigment production were ilmenite, slag, and rutile. The U.S.S.R. reportedly used a high-grade titaniferous slag for sponge metal production.

11. Substitutes: There is essentially no substitute for titanium for aircraft and space use. For industrial uses high-nickel steel, zirconium, and to a limited extent the superalloy metals may be substituted. There is no cost-effective substitute for TiO_2 pigment.

TUNGSTEN

(Data in metric tons of tungsten content, unless noted)

1. Domestic Production and Use: In 1987, all domestic tungsten concentrate production, as measured by domestic mine shipments, ceased. One mine in California initiated procedures for reopening late in the year. End uses of tungsten were: metalworking, mining, and construction machinery and equipment, 63%; lamps and lighting, 11%; electrical machinery and equipment, 10%; transportation, 9%; and other, 7%. The total estimated value of tungsten consumed in 1987 was $50 million.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production, mine shipments	1,016	1,173	983	817	-
Imports for consumption, concentrate	2,861	5,807	4,746	2,522	3,500
Exports, concentrate	1	129	124	34	-
Shipments from Govt. stockpile excesses, concentrate	259	1,368	902	301	850
Consumption: Reported, concentrate	5,181	8,577	6,838	4,804	4,800
Apparent, concentrate, scrap, metal	6,478	10,164	8,211	7,767	7,700
Price, concentrate, dollars/mtu WO_3 1/, average:					
U.S. market	85	85	68	46	50
European market	81	87	71	53	52
Stocks, producer and consumer, yearend, concentrate	1,132	1,005	1,137	523	300
Employment, mine and mill	300	287	275	187	77
Net import reliance 2/ as a percent of apparent consumption	52	70	68	70	80

3. Recycling: During 1987, the quantity of purchased scrap represented about 1,500 tons.

4. Import Sources (1983-86): China, 19%; Canada, 14%; Bolivia, 12%; Portugal, 7%; other, 48%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrate	601.54	17¢/lb. W cont.	50¢/lb. W cont.
Ferrotungsten	606.48	5.6% ad val.	35% ad val.
Unwrought lumps, grains, and powders	629.28	10.5% ad val.	58.0% ad val.
Ammonium tungstate	417.40	10.0% ad val.	49.5% ad val.
Tungsten carbide	422.40	10.5% ad val.	55.5% ad val.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile: In February, the General Services Administration sold 8 tons of nonstockpile-grade concentrate acquired under the Defense Production Act (DPA) of 1950. About 5 tons of DPA material remain available for disposal. In addition to quantities shown below, the stockpile contains the following nonstockpile-grade materials (in tons): Ore and concentrate, 10,991; metal powder, 151; ferrotungsten, 537; and carbide powder, 51. Authority for disposal of 464 tons of ore and concentrate was in effect as of September 30. Nonstockpile-grade disposals during the first 9 months in support of the ferroalloy upgrading program totaled 593 tons.

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Ore and concentrate	25,152	24,573	72	-
Metal powder	726	711	-	-
Ferrotungsten	-	381	-	-
Carbide powder	907	871	-	-

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e/ Estimated.

1/ A metric ton unit (mtu) of tungsten trioxide (WO_3) contains 7.93 kilograms of tungsten.

2/ Defined as imports - exports + adjustments for Government and industry stock changes.

3/ See page 184 for definitions.

Prepared by Gerald R. Smith, telephone number (202) 634-1029.

8. Events, Trends, and Issues: In 1987, additional mine closures and further underutilization of mine production capacity occurred worldwide. Estimated world production of tungsten in concentrate was about 2.5% less than that of 1986 owing to only slightly improved market prices and little or no change in the demand for tungsten products. Reported U.S. consumption of concentrate in 1987 was approximately the same as that of 1986. With the closing of all U.S. tungsten mines, concentrate for consumption was supplied solely from imports and shipments from Government stockpile excesses. Net import reliance as a percent of apparent consumption of tungsten materials was 80% in 1987 compared with 70% in 1986.

In 1987, the United States and China initiated a 4-year orderly marketing agreement regulating imports of ammonium paratungstate (APT) and tungstic acid (TA) from China. Under the terms of the agreement, which started in October, total Chinese imports of these materials will be limited each year to a prespecified quantity. The agreement also incorporates provisions to ensure that the effectiveness of the limits of APT and TA is not undermined by transshipment or by increased imports of tungsten oxide. The agreement is expected to provide the domestic tungsten industry with the needed import relief to help maintain a viable domestic processing industry.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States (mine shipments)	817	-	150,000	290,000
Australia	1,300	1,100	130,000	140,000
Austria	1,500	1,500	15,000	20,000
Bolivia	1,160	1,200	45,000	130,000
Brazil	800	800	20,000	20,000
Burma	715	700	15,000	15,000
Canada	1,416	-	480,000	670,000
France	982	-	20,000	20,000
Korea, Republic of	2,500	2,500	58,000	60,000
Portugal	1,637	1,700	40,000	40,000
Thailand	361	600	30,000	30,000
Other Market Economy Countries	2,573	2,600	232,000	260,000
China	15,000	17,000	1,200,000	1,230,000
U.S.S.R.	9,200	9,200	280,000	490,000
Other Centrally Planned Economies	2,550	2,500	85,000	105,000
World Total	42,511	41,400	2,800,000	3,520,000

10. World Resources: More than 90% of the world's estimated tungsten resources are located outside the United States, with about 50% located in China. Besides China and the United States, other areas with significant resource potential are in Australia, Austria, Bolivia, Brazil, Burma, Canada, Malaysia, North Korea, Peru, Portugal, the Republic of Korea, Thailand, Turkey, and the U.S.S.R.

11. Substitutes: Coatings, primarily aluminum oxide, titanium carbide, and titanium nitride, have improved the cutting and wear resistance of cemented tungsten carbide tool inserts. The use of coatings is expected to increase during the next few years. This extended wear capability of the inserts decreases the rate of replacement and, hence, the growth of tungsten consumption. Also, there will probably be a slow increase in the substitution of cemented tungsten carbide-based products by titanium carbide-based cutting tools, by ceramic cutting tools and wear parts, and by polycrystalline diamond.

VANADIUM

(Data in thousand pounds of vanadium content, unless noted)

1. Domestic Production and Use: The U.S. vanadium industry consisted of 11 firms in 1987, but only 6 had active extraction operations. Raw materials included Idaho ferrophosphorus slags, petroleum residues, utility ash, and imported iron slags. The chief use of vanadium was as an alloying agent for iron and steel. It was also important in the production of aerospace titanium alloys, and as a catalyst for production of sulfuric acid. About 140 plants throughout the United States reported consumption in 1987. Major end-use distribution: Machinery and tools, 33%; transportation, 30%; building and heavy construction, 26%; and other, 11%.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production:					
Mine, recoverable basis	4,342	3,234	W	W	W
Mill, recovered basis 1/	4,866	5,240	W	W	W
Petroleum residues, recovered basis	1,786	3,401	5,390	4,660	4,900
Imports for consumption:					
Ores, slags, residues	115	1,266	605	4,026	4,230
Vanadium pentoxide, anhydride	754	297	22	824	930
Ferrovanadium	1,361	2,341	1,557	1,189	1,570
Exports:					
Ores	117	24	5	172	103
Vanadium pentoxide, anhydride	2,967	4,158	1,710	1,730	1,557
Other compounds	114	366	386	346	350
Ferrovanadium	1,085	656	635	820	909
Shipments from Govt. stockpile excesses 2/	-	(136)	(224)	-	-
Consumption: Reported	6,554	9,522	9,766	8,616	9,047
Apparent 3/	6,602	11,458	W	W	W
Price, average, dollars per pound V_2O_5	3.50	3.50	3.50	3.50	3.50
Stocks, producer and consumer, yearend	9,674	7,540	6,418	5,463	5,641
Employment, mine and mill	800	660	580	585	636
Net import reliance 4/ as a percent of apparent consumption	26	54	W	W	W

3. Recycling: Some tool steel scrap was recycled primarily for its vanadium content. Vanadium was also recycled as a minor component of scrap iron and steel alloys, which were used principally for their iron content.

4. Import Sources (1983-86): 5/ Republic of South Africa, 53%; European Communities (EC), 16%; Canada, 8%; other, 23%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrate	601.60	Free	Free
Slags and residues	603.65	Free	Free
Ferrovanadium	606.50	4.2% ad val.	25% ad val.
Unwrought metal; waste & scrap	632.58	3.7% ad val.	25% ad val.
Ammonium vanadate	417.42	11.2% ad val.	40% ad val.
Potassium vanadate	420.34	11.2% ad val.	40% ad val.
Vanadium carbide	422.58	4.2% ad val.	25% ad val.
Vanadium pentoxide, anhydride	422.60	16.0% ad val.	40% ad val.
Vanadium compounds, other	422.62	16.0% ad val.	40% ad val.

e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Produced from domestic materials.
2/ Data in parentheses denote stockpile acquisitions.
3/ Includes processing losses from low-grade imports.
4/ Defined as imports - exports + adjustments for Government and industry stock changes.
5/ The EC, Canada and Austria produced vanadium alloys and chemicals solely from imported raw materials.
6/ Excludes U.S. production.
7/ See page 184 for definitions.
8/ Includes data for Bophuthatswana.

Prepared by Henry E. Hilliard, telephone number (202) 634-1015.

6. Depletion Allowance: 22% (Domestic), 14% (Foreign).

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months	Purchases, 9 Months
Vanadium pentoxide	15,400	1,442	-	-	-
Ferrovanadium	2,000	-	-	-	-

8. Events, Trends, and Issues: The restructuring of the U.S. vanadium industry that began in 1984 continued throughout 1987. Mergers and buy-outs reduced the number of competitors in the market without a significant reduction in capacity. For the second consecutive year the U.S. Department of Energy determined that the uranium industry was not viable. The uranium-vanadium producers in the Colorado Plateau were encouraged by a circuit court ruling prohibiting the Department of Energy from enriching foreign uranium as long as the uranium industry is not viable. On January 7, 1987, pursuant to Section 303(a) (2) of the Comprehensive Anti-Apartheid Act of 1986, vanadium was certified by the U.S. State Department as a strategic mineral essential for the economy or defense of the United States that is unavailable in adequate supplies from reliable and secure suppliers.

In Finland, the extraction plant and process technology from the dormant vanadium industry was sold to a company in Brazil. In Brazil, the technology will be used to begin production from an ore deposit in the municipal district of Maracas, Bahia State. Finland will also supply equipment and technology to the U.S.S.R. where it will be used to process ore from deposits in the Tsaginsk and neighboring deposits under development on the Kola peninsula.

Production of Nitrovan, a proprietary vanadium pentoxide derivative used as an alloying agent for steel, was scheduled to begin in the United States in 1987. Currently the additive is produced only in Brits, the Republic of South Africa.

9. World Mine Production, Reserves, and Reserve Base:

	Production 6/		Reserves 7/	Reserve Base 7/
	1986	1987 e/		
United States	W	W	300,000	4,800,000
Australia	-	-	70,000	540,000
Finland	-	-	-	200,000
South Africa, Republic of 8/	34,400	34,000	1,900,000	17,200,000
Other Market Economy Countries	-	-	-	1,200,000
China	9,000	10,000	1,340,000	3,600,000
U.S.S.R.	21,000	21,000	5,800,000	9,000,000
World Total (may be rounded)	64,400	65,000	9,410,000	36,500,000

10. World Resources: World resources of vanadium exceed 140 billion pounds. Vanadium occurs in deposits of titaniferous magnetite, phosphate rock, and uraniferous sandstones and siltstones, where it constitutes less than 2% of the host rock. Significant amounts are also present in bauxite and carboniferous materials such as crude oil, coal, oil shale, and tar sands. Because vanadium is generally recovered as a byproduct or coproduct, demonstrated world resources of the element are not fully indicative of available supplies. While domestic resources are adequate to supply current domestic needs, a substantial part of U.S. demand is currently met by foreign material because of price advantages.

11. Substitutes: Steels containing various combinations of other alloying metals can be substituted for steels containing vanadium. Among the various metals that are interchangeable with vanadium are columbium, molybdenum, manganese, titanium, and tungsten. There is currently no acceptable substitute for vanadium in aerospace titanium alloys. Platinum and nickel can replace vanadium compounds as a catalyst in some chemical processes.

VERMICULITE

(Data in thousand short tons, unless noted)

1. Domestic Production and Use: Value of production from five operations was $33 million in 1987. One company, operating an open pit in Montana and several pits in South Carolina, continued as the principal producer of vermiculite. Most of the vermiculite concentrate was shipped to 41 exfoliating plants in 28 States. The major uses for exfoliated vermiculite were agriculture, 23%; insulation, 23%; plaster and cement premixes, 32%; and lightweight concrete aggregate, 20%.

2. Salient Statistics--United States:

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production 1/	282	315	314	317	300
Imports for consumption e/	24	32	38	35	35
Exports	19	22	23	25	20
Consumption, apparent, concentrate	287	325	329	327	315
Consumption, exfoliated	224	264	258	258	250
Price, average value, dollars per ton, f.o.b. mine	96.45	100.00	103.18	108.52	110.00
Stocks, producer, yearend		Not available			
Employment, mine and mill e/	300	300	250	260	260
Net import reliance 2/ as a percent of apparent consumption	2	3	5	3	5

3. Recycling: Insignificant.

4. Import Sources (1983-86): Republic of South Africa, 99%; Brazil, 1%.

5. Tariff:

Item	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Crude or processed	523.81	Free	Free

6. Depletion Allowance: 14% (Domestic), 14% (Foreign).

7. Government Stockpile: None.

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e/ Estimated. NA Not available.
1/ Concentrate sold and used by producers.
2/ Defined as imports - exports + adjustments for Government and industry stock changes.
3/ See page 184 for definitions.
4/ Excludes Centrally Planned Economies.

Prepared by Arthur C. Meisinger, telephone number (202) 634-1185.

8. **Events, Trends, and Issues:** Transportation costs from the mine to exfoliation plants near the point of end use continued to limit the size of the market as well as vermiculite's competitive position with respect to other mineral commodities. The number of operating quarries is small, and the industry does not have any severe environmental problems. It is estimated that in 1988, domestic production of vermiculite concentrate will be 320,000 tons.

9. **World Mine Production, Reserves, and Reserve Base:**

	Mine Production		Reserves 3/	Reserve Base 3/
	1986	1987 e/		
United States	1/317	1/300	25,000	100,000
South Africa, Republic of	213	220	20,000	80,000
Other Market Economy Countries	40	40	5,000	20,000
Centrally Planned Economies	NA	NA	NA	NA
World Total 4/	570	560	50,000	200,000

10. **World Resources:** Marginal reserves of vermiculite, which occur in North Carolina, Texas, Wyoming, Colorado and Nevada, are estimated to be 2 million to 3 million tons. Resources in other market economy countries and in centrally planned economies usually include material that has exfoliation characteristics considered to be inferior to U.S. and South African vermiculite. Total world resources are estimated to be up to three times the reserves.

11. **Substitutes:** Expanded perlite is a substitute for vermiculite in lightweight concrete and plaster. Other more dense but less costly substitutes in these applications are expanded clay, shale, slate or slag. Alternate materials for loosefill fireproofing insulation include fiberglass, perlite, and slag wool. In agriculture, substitutes include peat, perlite, sawdust, bark and other plant materials, and synthetic soil conditioners.

YTTRIUM 1/

(Data in metric tons of yttrium oxide (Y_2O_3) content, unless noted)

1. Domestic Production and Use: In 1987, two companies mined the yttrium-bearing rare-earth minerals bastnasite and monazite. Bastnasite was mined in California for its rare-earth content, and small amounts of yttrium were extracted as a byproduct during processing. Monazite was recovered as a byproduct of processing heavy minerals sands for titanium and zirconium minerals by one company in Florida, however, all of it was exported, and the contained yttrium was not recovered domestically. Most purified yttrium metal and compounds produced and used in the United States were derived from imported yttrium concentrate and high-purity yttrium oxide. Three companies processed concentrates in 1987 to produce high-purity and intermediate yttrium products in Arizona, Colorado, and Texas. Yttrium metal and compounds were used in phosphors in color television and computer monitors, laser crystals and glass, zirconia electrolyte, nickel- and cobalt-base superalloys, emission control catalyst substrates, heating elements, synthetic garnets for microwave and other electronic applications, and in advanced ceramic materials. Companies producing and processing yttrium products were located throughout the United States. Yttrium, which is chemically similar to the rare-earth elements and not always separated from them, is a functioning constituent of some rare-earth alloys and compounds.

2. Salient Statistics--United States:

	1983	1984	1985	1986	1987 e/
Production, mine and refinery	W	W	W	W	W
Imports for consumption:					
In Monazite	44	62	62	49	12
In Xenotime and yttrium concentrate 2/3/	W	W	W	W	W
Exports, in ore and concentrate e/	3	5	8	7	9
Shipments from Gov't stockpile excesses	-	-	-	4/	-
Consumption, apparent e/5/	53	63	15	42	3
Price, dollars, yearend 1987: Monazite concentrates, 581 per ton or 52.84 per kilogram contained yttrium oxide; yttrium concentrates (60% Y_2O_3), 35 per kilogram of contained yttrium oxide; yttrium oxide, 115-450 per kilogram depending on purity; yttrium metal, 510 per kilogram.					
Stocks, processor, yearend	W	W	W	W	W
Employment	Not available				
Net import reliance 5/6/ as a percent of apparent consumption	100	100	100	100	100

3. Recycling: None.

4. Import Sources (1983-86): Monazite--Australia, 96%; other, 4%.

5. Tariff:

	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrates	601.12 & 601.45	Free	Free
Yttrium oxide	423.00	3.7% ad val.	25.0% ad val.
Metal	632.38	3.7% ad val.	25.0% ad val.
Alloys	632.78	32¢/lb	$2/lb
Yttrium materials and compounds (yttrium concentrate)	907.51	Free	7/25.0% ad val. or 30% ad val.

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.

1/ See also Rare-Earth Metals and Thorium.

2/ Xenotime is chemically treated to produce yttrium concentrate.

3/ Data on xenotime and yttrium concentrate reported by processors.

4/ Less than 1 unit.

5/ Most, or all, of the consumed yttrium was imported, or refined from imported ore or concentrate. U.S. production assumed to be zero for apparent consumption and net import reliance calculations.

6/ Defined as imports - exports + adjustments for Government and industry stock changes.

7/ Tariff is 25% if previous import item classification was 423.00 or 423.96, part 2C, schedule 4, or 30% if 603.70, part 1, schedule 6.

8/ Includes yttrium contained in rare-earth ores.

9/ See page 184 for definitions.

10/ Excludes U.S. mine production.

Prepared by James B. Hedrick, telephone number (202) 634-1058.

6. Depletion Allowance: Monazite: 22% on thorium content and 14% on yttrium and rare earth content (Domestic), 14% (Foreign). Xenotime: 14% (Domestic and Foreign).

7. Government Stockpile: None

8. Events, Trends, and Issues: Yttrium supplies were adequate in 1987, as a result of additional materials available from Canada and China. Demand for yttrium used in television and lighting phosphors, and in electronic applications such as laser crytals and synthetic garnets, remained steady, while demand for yttrium used in stabilized zirconia and other ceramic applications continued to gain market share. Imports of yttrium-bearing monazite, for use in manufacturing petroleum fluid cracking catalysts, continued to decrease as a result of decreased demand for lower octane gasoline requiring lead additives. It is estimated that in 1988 domestic mine production of yttrium contained in monazite will be essentially the same as that of 1987.

   An yttrium processing plant at Elliot Lake, Ontario, Canada, that began solvent extraction processing in September of 1986 produced yttrium concentrate in 1987. Concentrate from the plant was to be processed into high purity yttrium oxide in the United States and Japan. A new 100-ton-per-year rare-earth/yttrium separation plant was being constructed in Takefu, Japan, to process some of the yttrium concentrates from Canada. The plant was scheduled for completion in 1987. Feed material for the plant was also to come from a rare-earth and yttrium processing plant in Tennessee. About 75 tons of rare earth and yttrium concentrates from each of the two North American operations was expected to feed the new plant.

   The impact of the world's production and use of yttrium products on the environment was generally minimal, but certain yttrium placer reserves and resources, principally monazite, were excluded from production because of environmental considerations. Mine reclamation of placers has been successful in many areas, as the recovery of economic heavy minerals typically involves removal of only a small percentage of material.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production e/ 8/		Reserves 9/	Reserve Base 9/
	1986	1987		
United States	W	W	117,000	130,000
Australia	116	120	6,900	7,600
Brazil	66	66	400	1,500
Canada	-	50	3,300	4,000
India	44	44	36,000	38,000
Malaysia	216	216	12,600	21,000
Thailand	15	15	600	660
Other Market Economy Countries	2	2	3,500	34,000
China	135	140	720,000	720,000
Other Centrally Planned Economies	30	30	9,000	10,000
World Total (rounded)	10/620	10/680	910,000	970,000

10. World Resources: Large resources of yttrium in monazite and xenotime are available worldwide in placer and beach-sand deposits and uranium ores. Additional large subeconomic resources of yttrium occur in other monazite-bearing deposits, apatite-magnetite rocks, sedimentary phosphate deposits, deposits of columbium-tantalum minerals, and certain uranium ores, especially those of the Blind River district, Canada. It is probable that the world's resources are very large relative to expected demand.

11. Substitutes: Substitutes for yttrium are available for some applications, but generally are much less effective. In most uses, especially in phosphors, electronics, and ceramics, yttrium is not subject to substitution by other elements.

ZINC

(Data in thousand metric tons of zinc content, unless noted)

1. **Domestic Production and Use:** The value of mine production in 1987, based on the price of metal, was $202 million. The 25 leading mines accounted for 99% of mine output, with the leading five producing 55%. About 85% of the total mine output was produced in Tennessee, New York, and Missouri. Four primary and eight secondary smelters produced slab zinc. About 60% of the slab consumption was by approximately 200 firms in Illinois, Indiana, New York, Ohio, and Pennsylvania. Construction materials accounted for about 50% of slab zinc consumption; transportation, 23%; machinery, 12%; electrical, 10%; and other, 10%. Of the total slab zinc consumed, galvanizing accounted for 50%; zinc-base alloys, 27%; brass and bronze, 13%; and other, 10%. About 230,000 tons of zinc in compounds and dusts were consumed mainly by the chemical, agricultural, rubber, and paint industries. Major coproducts of zinc mining and smelting were lead, cadmium, silver, and sulfur.

2. **Salient Statistics--United States:**

Salient Statistics--United States:	1983	1984	1985	1986	1987 e/
Production: Mine	275	253	227	203	220
Primary slab zinc	236	253	261	253	260
Secondary slab zinc	69	78	73	63	70
Imports for consumption: Ore and concentrates	63	86	90	76	26
Slab zinc, scrap, and compounds	664	694	665	724	744
Exports: Slab zinc, scrap, and compounds	24	43	47	73	82
Ore and concentrates	60	31	23	3	8
Shipments from Govt. stockpile excesses			None		
Consumption: Reported, slab zinc	806	849	771	706	800
Apparent, slab zinc	933	980	961	999	985
Apparent, all forms	1,005	1,051	1,005	1,017	990
Price, average, cents per pound:					
U.S. High Grade metal	41.4	48.6	40.4	38.0	41.6
London, Prime Western equivalent	34.7	40.5	36.2	34.2	37.0
Stocks, slab zinc, yearend	148	138	120	101	101
Employment: Mine and mill e/	2,900	2,800	2,600	2,000	2,000
Smelter, primary e/	1,600	2,000	1,600	1,600	1,600
Net import reliance 1/ as a percent of apparent consumption	65	68	70	73	69

3. **Recycling:** In 1987, an estimated 350,000 tons of zinc in waste and scrap, including 90,000 tons of old zinc scrap, was recovered in the form of slab zinc, brass, zinc-based alloys, dust, oxide, and other chemicals.

4. **Import Sources (1983-86):** Ore, concentrates--Canada, 39%; Peru, 19%; Mexico, 18%; Honduras, 16%; other, 8%.
Metal--Canada, 55%; Mexico, 9%; Peru, 6%; Australia, 5%; other, 25%.
Combined total--Canada, 53%; Mexico, 10%; Peru, 8%; Australia, 6%; other, 23%.

5. **Tariff:**

Tariff:	Number:	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Ore and concentrate	602.20	2/0 3¢/lb	1.67¢/lb
Unwrought metal	626.02	1.5% ad val.	1.75¢/lb
Alloys	626.04	19.0% ad val.	45.0% ad val.
Waste and scrap	626.10	2/2.1% ad val.	11.0% ad val.

6. **Depletion Allowance:** 22% (Domestic), 14% (Foreign).

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e/ Estimated.
1/ Defined as imports - exports + adjustments for Government and industry stock changes.
2/ Duty suspended until December 1989, as provided by P.L. 98-573.
3/ World production is zinc content of concentrate and direct shipping ore.
4/ See page 184 for definitions.

Prepared by James H. Jolly, telephone number (202) 634-1063.

7. Government Stockpile:

Stockpile Status--9-30-87

Material	Goal	Total Inventory	Excess to Goal Authorized For Disposal	Sales, 9 Months
Zinc	1,293	343	-	-

8. Events, Trends, and Issues: Domestic mine output trended upward in 1987, reversing a 6-year downtrend in production. The increase was attributable to the opening of a new mine in Montana and the reopening of mines in Idaho and Missouri. In 1988, zinc mine production was expected to increase further, reflecting full-year output at the mines opened in 1987 and to the opening of a new mine in Alaska late in the year. Initial production at another Alaskan deposit, expected to be the world's largest zinc producer, was advanced 1 year to 1990.

Domestic metal production was up marginally in 1987, mainly owing to the reopening of a secondary plant in Michigan. In 1988 a further small increase in metal output was expected, reflecting largely expectations of higher operating rates at the four operating primary zinc plants. The Texas zinc smelter that closed in April 1985, was expected to remain closed in 1988. The domestic zinc industry contracted further in 1987 owing to a merger between two major domestic zinc companies in September. The new company has available capacity to be the largest domestic processor of both primary and secondary materials and, consequently, the Nation's largest producer of slab zinc, zinc oxide, zinc dust, and some zinc chemicals.

Zinc consumption fell marginally in 1987, owing mainly to reductions in domestic automobile manufacture, reduced Mint buying for penny production, and decreases in some construction sectors. The galvanizing and electrogalvanizing sector continued as the main use of zinc, constituting about one-half of the slab zinc consumption. Because of anticipated slower growth in the economy, zinc consumption in 1988 was expected to decrease slightly from the 1987 level. Zinc prices, which fell in the first few months of 1987 to a low of about 37 cents per pound for U.S. High Grade metal, rose sharply at midyear to almost 46 cents owing to supply tightness largely caused by an extended strike at a Canadian zinc smelter. Prices declined into the 40- to 43-cent range from September largely in response to settlement of the Canadian strike and increased availability of zinc supplies.

Environmental concerns in both the primary and secondary zinc industries are more associated with coproduct elements, such as lead, cadmium, and sulfur, than with zinc. In response to a upcomming ban on the dumping of untreated zinc-bearing electric-arc furnace (EAF) steelmaking dusts in land fills, increased amounts of EAF dusts were processed to extract zinc and render the remaining product nonhazardous. The potential annual recovery of zinc from this source in the United States is about 100,000 tons or about 10% of U.S. zinc demand.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production 3/		Reserves 4/	Reserve Base 4/
	1986	1987 e/		
United States	221	240	21,000	50,000
Australia	662	686	18,000	49,000
Canada	1,294	1,480	25,000	56,000
Mexico	285	294	6,000	8,000
Peru	597	532	7,000	12,000
Other Market Economy Countries	2,094	2,024	48,000	84,000
Centrally Planned Economies	1,700	1,800	23,000	36,000
World Total	6,853	7,056	148,000	295,000

10. World Resources: Identified zinc resources of the world are estimated at about 1.8 billion tons. Sphalerite-bearing coals, best known in the mid-continent United States, have a resource potential of many millions of tons of zinc that could possibly be recovered as a byproduct of coal mining with limited modification of existing technology.

11. Substitutes: Aluminum, plastics, and magnesium are the major substitutes for die casting uses. Aluminum and plastic sheet and molded plastics substitute for galvanized sheet and formed products. Plastic coatings, paints, electroplated cadmium, and aluminum-zinc coatings can replace zinc in limited areas for corrosion protection, and aluminum alloys can be used in place of brass. Aluminum, magnesium, titanium, and zirconium are significant competitors of zinc in chemicals and pigments.

January 1988

ZIRCONIUM 1/

(Data in short tons, unless noted)

1. **Domestic Production and Use**: Two companies, one with a plant in Oregon and another with a plant in Utah, produced primary zirconium sponge and coproduct hafnium sponge in 1987. These firms also converted zirconium sponge to ingot. Zircon, the only significant domestic ore mineral of zirconium and hafnium, was extracted in 1987 from sand deposits, as a coproduct of ilmenite and rutile, by two firms in Florida. The value of reported consumption of zircon in 1987 was about $23 million. Most zircon was used in the Eastern United States; 35% was used in foundry sands, 28% in refractories, 20% in ceramics, 5% in abrasives, and 12% in miscellaneous uses, including the manufacture of chemicals and production of zirconium metal and alloys for nuclear applications and for chemical processing equipment.

2. **Salient Statistics--United States**:

	1983	1984	1985	1986	1987 e/
Production: Zircon	W	W	W	W	W
Zirconium metal	W	W	W	W	W
Imports for consumption:					
Zircon 2/	44,487	66,436	43,787	75,799	60,000
Zirconium metal	383	565	450	349	400
Exports: Zircon	13,222	9,528	16,855	17,474	20,000
Zirconium, alloys, and scrap	747	808	1,153	1,190	1,100
Consumption: Reported, zircon 3/	100,000	130,000	130,000	135,000	135,000
Apparent, zircon	W	W	W	W	W
Price, zircon, domestic, dollars per ton, yearend	165	165	175	190	230
Stocks, zircon, consumer and dealer, yearend 4/	36,498	32,861	29,288	30,916	20,000
Employment: Mine and mill	325	375	375	375	375
Metal plant	1,750	1,800	1,800	1,800	1,800
Net import reliance 5/ as a percent of apparent consumption	W	W	W	W	W

3. **Recycling**: Insignificant.

4. **Import Sources (1983-86)**: Zirconium: France, 72%; Japan, 7%; Canada, 7%; other, 14%. Zircon: Australia, 63%; Republic of South Africa, 27%; other, 10%.

5. **Tariff**:

	Number	Most Favored Nation (MFN) 1/1/87	Non-MFN 1/1/87
Zirconium oxide	422.80	3.7% ad val.	25.0% ad val.
Other zirconium compounds	422.82	3.7% ad val.	25.0% ad val.
Zirconium ore & concentrate	601.63	Free	Free
Unwrought zirconium, waste and scrap	629.60	4.2% ad val.	25.0% ad val.
Unwrought zirconium alloys	629.62	4.9% ad val.	25.0% ad val.
Wrought zirconium	629.65	5.5% ad val.	45.0% ad val.

6. **Depletion Allowance**: 22% (Domestic), 14% (Foreign).

7. **Government Stockpile**: None.

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e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ See also Hafnium.
2/ Includes baddeleyite (zirconium oxide): 1983, 1,000 tons; 1984, 1,200 tons; 1985, 1,400 tons; 1986, 1090 tons; 1987, 1,000 tons e/.
3/ Based on incomplete reported data.
4/ Excludes foundries.
5/ Defined as imports - exports + adjustments for Government and industry stock changes.
6/ See page 184 for definitions.
7/ Excludes U.S. production.

Prepared by W. Timothy Adams, telephone number (202) 634-1058.

8. Events, Trends, and Issues: The output of zircon by U.S. producers in 1987 was approximately the same as that of 1986. The production of zirconium metal also was about the same as that of 1986. Zircon imports, mostly from Australia, decreased somewhat, while exports increased. It is estimated that in 1988 U.S. reported consumption of zircon will be about 135,000 short tons. The use of zircon in refractories, ceramics, and chemicals is expected to grow, as is the use of zirconium metal in refractory and corrosion-resistant alloys, but the metal's use in nuclear reactors is expected to remain essentially unchanged.

World demand for zircon is presently increasing more rapidly than sources of heavy mineral sands can be brought into production. Increased applications in refractories for steel production, in substrates in electronic applications, and in the production of glazes, stains, and colors for ceramic tile and porcelain enamels are mainly responsible for the rapid increase in demand. A substantial worldwide deficit for zircon developed in 1987 and a deficit of about 100,000 tons is expected in 1988.

Reportedly two additional sources of heavy mineral sands, including zircon, began production in 1987. One supplier in New Jersey was reprocessing the tailings of a worked-out ilmenite deposit. The other supplier, a sand and gravel company in California, reportedly was reprocessing the tailings from construction material deposits.

9. World Mine Production, Reserves, and Reserve Base:

	Mine Production		Reserves 6/	Reserve Base 6/
	1986	1987 e/		
United States	W	W	4,000,000	8,000,000
Australia	443,000	450,000	8,700,000	14,900,000
India	17,600	17,600	1,800,000	3,000,000
South Africa, Republic of e/	176,400	180,000	3,400,000	12,100,000
Other Market Economy Countries	26,200	27,000	1,950,000	7,050,000
China e/	16,500	16,500	400,000	1,000,000
U.S.S.R. e/	95,000	95,000	3,000,000	5,000,000
World Total (may be rounded)	7/774,700	7/790,000	23,000,000	51,000,000

10. World Resources: Resources of zircon in the United States include about 14 million tons associated with titanium resources in sand deposits, occurring mainly in the Atlantic and Gulf Coast States. Phosphate, and sand and gravel deposits may yield substantial amounts of zircon as a byproduct in the future. Identified world resources of zircon exceed 60 million tons.

11. Substitutes: Foundry sands--chromite, olivine, staurolite.
Ceramic glazes and enamels--oxides of titanium and tin.
Nuclear reactors--stainless steel, aluminum, columbium, vanadium.
Corrosion-resistant metals--stainless steel, titanium, tantalum.
Steel production--other refractories.

RESOURCE RESERVE DEFINITIONS

(From Geological Survey Circular 831, 1980.)

Principles of a Resource/Reserve Classification for Minerals

By the U.S. BUREAU OF MINES and the U.S. GEOLOGICAL SURVEY

INTRODUCTION

Through the years, geologists, mining engineers, and others operating in the minerals field have used various terms to describe and classify mineral resources, which as defined herein include energy materials. Some of these terms have gained wide use and acceptance, although they are not always used with precisely the same meaning.

Staff members of the U.S. Bureau of Mines and the U.S. Geological Survey collect information about the quantity and quality of all mineral resources, but from different perspectives and with different purposes. In 1976, a team of staff members from both agencies developed a common classification and nomenclature, which was published as U.S. Geological Survey Bulletin 1450-A – "Principles of the Mineral Resource Classification System of the U.S. Bureau of Mines and U.S. Geological Survey." Experience with this resource classification system showed that some changes were necessary in order to make it more workable in practice and more useful in long-term planning. Therefore, representatives of the U.S. Geological Survey and the U.S. Bureau of Mines collaborated to revise Bulletin 1450-A.

Long-term public and commercial planning must be based on the probability of discovering new deposits, on developing economic extraction processes for currently unworkable deposits, and on knowing which resources are immediately available. Thus, resources must be continuously reassessed in the light of new geologic knowledge, of progress in science and technology, and of shifts in economic and political conditions. To best serve these planning needs, known resources should be classified from two standpoints: (1) purely geologic or physical/chemical characteristics – such as grade, quality, tonnage, thickness, and depth – of the material in place; and (2) profitability analyses based on costs of extracting and marketing the material in a given economy at a given time. The former constitutes important objective scientific information of the resource and a relatively unchanging foundation upon which the latter more variable economic delineation can be based.

The revised classification system, designed generally for all mineral materials, is shown graphically in figures 1 and 2 (see page 5); its components and their usage are described in the text. The classification of mineral and energy resources is necessarily arbitrary, because definitional criteria do not always coincide with natural boundaries. The system can be used to report the status of mineral and energy-fuel resources for the Nation or for specific areas.

RESOURCE/RESERVE DEFINITIONS

A dictionary definition of resource, "something in reserve or ready if needed," has been adapted for mineral and energy resources to comprise all materials, including those only surmised to exist, that have present or anticipated future value.

Resource. – A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Original Resource. – The amount of a resource before production.

Identified Resources. – Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. *Identified resources* include economic, marginally economic, and subeconomic components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into *measured, indicated,* and *inferred.*[1]

Demonstrated. – A term for the sum of *measured* plus *indicated.*

Measured. – Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and(or) quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, depth, and mineral content of the resource are well established.

Indicated. – Quantity and grade and(or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume continuity between points of observation.

Inferred. – Estimates are based on an assumed continuity beyond measured and(or) indicated resources, for which there is geologic evidence. *Inferred resources* may or may not be supported by samples or measurements.

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[1] The terms "proved," "probable," and "possible," which are commonly used by industry in economic evaluations of ore or mineral fuels in specific deposits or districts, have been loosely interchanged with the terms measured, indicated, and inferred. The former terms are not a part of this classification system.

Reserve Base. – That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The *reserve base* is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The *reserve base* includes those resources that are currently economic (*reserves*), marginally economic (*marginal reserves*), and some of those that are currently subeconomic (*subeconomic resources*). The term "geologic reserve" has been applied by others generally to the *reserve-base* category, but it also may include the *inferred-reserve-base* category; it is not a part of this classification system.

Inferred Reserve Base. – The in-place part of an identified resource from which inferred reserves are estimated. Quantitative estimates are based largely on knowledge of the geologic character of a deposit and for which there may be no samples or measurements. The estimates are based on an assumed continuity beyond the reserve base, for which there is geologic evidence.

Reserves. – That part of the reserve base which could be economically extracted or produced at the time of determination. The term *reserves* need not signify that extraction facilities are in place and operative. *Reserves* include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

Marginal Reserves. – That part of the reserve base which, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible, given postulated changes in economic or technologic factors.

Economic. – This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Subeconomic Resources. – The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Undiscovered Resources. – Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. *Undiscovered resources* may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or subeconomic. To reflect varying degrees of geologic certainty, undiscovered resources may be divided into two parts:

Hypothetical Resources. – Undiscovered resources that are similar to known mineral bodies and that may be reasonably expected to exist in the same producing district or region under analogous geologic conditions. If exploration confirms their existence and reveals enough information about their quality, grade, and quantity, they will be reclassified as identified resources.

Speculative Resources. – Undiscovered resources that may occur either in known types of deposits in favorable geologic settings where mineral discoveries have not been made, or in types of deposits as yet unrecognized for their economic potential. If exploration confirms their existence and reveals enough information about their quantity, grade, and quality, they will be reclassified as identified resources.

Restricted Resources/Reserves. – That part of any resource/reserve category that is restricted from extraction by laws or regulations. For example, *restricted reserves* meet all the requirements of reserves except that they are restricted from extraction by laws or regulations.

GUIDELINES FOR CLASSIFICATION OF MINERAL RESOURCES

1. All naturally occurring metals, nonmetals, and fossil fuels in sufficient concentration can be classified in one or more of the categories.

2. Where the term *reserves* is used alone, without a modifying adjective such as indicated, marginal, or inferred, it is to be considered synonymous with the demonstrated-economic category, as shown in figure 1.

3. Definitions of resource categories can be modified for a particular commodity in order to conform with accepted usage involving special geological and engineering characteristics. Such modified definitions for particular commodities will be given in forthcoming government publications.

4. Quantities, qualities, and grades may be expressed in different terms and units to suit different purposes, but usage must be clearly stated and defined.

5. The geographic area to which any resource/reserve estimate refers must be defined.

6. All estimates must show a date and author.

7. The *reserve base* is an encompassing resource category delineated by physical and chemical criteria. A major purpose for its recognition and appraisal is to aid in long-range public and commercial planning. For most mineral commodities, different grades and tonnages, or other appropriate resource parameters, can be specified

for any given deposit or area, or for the Nation, depending on the specific objectives of the estimators; therefore, the position of the lower boundary of the reserve base, which extends into the subeconomic category, is variable, depending on those objectives. The intention is to define a quantity of in-place material, any part of which may become economic, depending on the extraction plans and economic assumptions finally used. When those criteria are determined, the initial reserve-base estimate will be divided into three component parts: reserves, marginal reserves, and a remnant of subeconomic resources. For the purpose of Federal commodity assessment, criteria for the reserve base will be established for each commodity.

8. *Undiscovered resources* may be divided in accordance with the definitions of *hypothetical* and *speculative resources*, or they may be divided in terms of relative probability of occurrence.

9. *Inferred reserves* and the *inferred reserve base* are postulated extensions of reserves and of the reserve base. They are identified resources quantified with a relatively low degree of certainty. Postulated quantities of resources not based on reserve/reserve-base extensions, but rather on geologic inference alone, should be classified as undiscovered.

10. Locally, limited quantities of materials may be produced, even though economic analysis has indicated that the deposit would be too thin, too low grade, or too deep to be classified as a reserve. This situation might arise when the production facilities are already established or when favorable local circumstances make it possible to produce material that elsewhere could not be extracted profitably. Where such production is taking place, the quantity of in-place material shall be included in the reserve base, and the quantity that is potentially producible shall be included as a reserve. The profitable production of such materials locally, however, should not be used as a rationale in other areas for classifying as reserves, those materials that are similar in thickness, quality, and depth.

11. Resources classified as reserves must be considered economically producible at the time of classification. Conversely, material not currently producible at a profit cannot be classified as reserves. There are situations, however, in which mining plans are being made, lands are being acquired, or mines and plants are being constructed to produce materials that do not meet economic criteria for reserve classification under current costs and prices, but would do so under reasonable future expectations. For some other materials, economic producibility is uncertain only for lack of detailed engineering assessment. The marginal-reserves category applies to both situations. When economic production appears certain for all or some of a marginal reserve, it will be reclassified as reserves.

12. Materials that are too low grade or for other reasons are not considered potentially economic, in the same sense as the defined resource, may be recognized and their magnitude estimated, but they are not classified as resources. A separate category, labeled *other occurrences*, is included in figures 1 and 2.

13. In figure 1, the boundary between *subeconomic* and *other occurrences* is limited by the concept of *current or potential feasibility of economic production*, which is required by the definition of a resource. The boundary is obviously uncertain, but limits may be specified in terms of grade, quality, thickness, depth, percent extractable, or other economic-feasibility variables.

14. Varieties of mineral or energy commodities, such as bituminous coal as distinct from lignite, may be separately quantified when they have different characteristics or uses.

15. The amount of past cumulative production is not, by definition, a part of the resource. Nevertheless, a knowledge of what has been produced is important to an understanding of current resources, in terms of both the amount of past production and the amount of residual or remaining in-place resource. A separate space for cumulative production is shown in figure 1. Residual material left in the ground during current or future extraction should be recorded in the resource category appropriate to its economic-recovery potential.

16. In classifying reserves and resources, it is necessary to recognize that some minerals derive their economic viability from their coproduct or byproduct relationships with other minerals. Such relationships must be clearly explained in footnotes or in an accompanying text.

17. Considerations other than economic and geologic, including legal, regulatory, environmental, and political, may restrict or prohibit the use of all or part of a deposit. Reserve and resource quantities known to be restricted should be recorded in the appropriate classification category; the quantity restricted and the reason for the restriction should be noted.

18. The classification system includes more divisions than will commonly be reported or for which data are available. Where appropriate, divisions may be aggregated or omitted.

19. The data upon which resource estimates are based and the methods by which they are derived are to be documented and preserved.

RESOURCES OF (commodity name)

[A part of reserves or any resource category may be restricted from extraction by laws or regulations (see text)]

AREA: (mine, district, field, State, etc.) UNITS: (tons, barrels, ounces, etc.)

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Other Occurrences	Includes nonconventional and low-grade materials

Author: Date:

Figure 1. – Major elements of mineral-resource classification, excluding *reserve base* and *inferred reserve base*.

RESOURCES OF (commodity name)

[A part of reserves or any resource category may be restricted from extraction by laws or regulations (see text)]

AREA: (mine, district, field, State, etc.) UNITS: (tons, barrels, ounces, etc.)

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserve Base		Inferred Reserve Base		
MARGINALLY ECONOMIC					
SUB-ECONOMIC					

Other Occurrences	Includes nonconventional and low-grade materials

Author: Date:

Figure 2. – *Reserve base* and *inferred reserve base* classification categories.

RESOURCE RESERVE DEFINITIONS

(From Geological Survey Circular 831, 1980.)

Principles of a Resource/Reserve Classification for Minerals

By the U.S. BUREAU OF MINES and the U.S. GEOLOGICAL SURVEY

INTRODUCTION

Through the years, geologists, mining engineers, and others operating in the minerals field have used various terms to describe and classify mineral resources, which as defined herein include energy materials. Some of these terms have gained wide use and acceptance, although they are not always used with precisely the same meaning.

Staff members of the U.S. Bureau of Mines and the U.S. Geological Survey collect information about the quantity and quality of all mineral resources, but from different perspectives and with different purposes. In 1976, a team of staff members from both agencies developed a common classification and nomenclature, which was published as U.S. Geological Survey Bulletin 1450-A–"Principles of the Mineral Resource Classification System of the U.S. Bureau of Mines and U.S. Geological Survey." Experience with this resource classification system showed that some changes were necessary in order to make it more workable in practice and more useful in long-term planning. Therefore, representatives of the U.S. Geological Survey and the U.S. Bureau of Mines collaborated to revise Bulletin 1450-A.

Long-term public and commercial planning must be based on the probability of discovering new deposits, on developing economic extraction processes for currently unworkable deposits, and on knowing which resources are immediately available. Thus, resources must be continuously reassessed in the light of new geologic knowledge, of progress in science and technology, and of shifts in economic and political conditions. To best serve these planning needs, known resources should be classified from two standpoints: (1) purely geologic or physical/chemical characteristics–such as grade, quality, tonnage, thickness, and depth–of the material in place: and (2) profitability analyses based on costs of extracting and marketing the material in a given economy at a given time. The former constitutes important objective scientific information of the resource and a relatively unchanging foundation upon which the latter more variable economic delineation can be based.

The revised classification system, designed generally for all mineral materials, is shown graphically in figures 1 and 2 (see page 5); its components and their usage are described in the text. The classification of mineral and energy resources is necessarily arbitrary, because definitional criteria do not always coincide with natural boundaries. The system can be used to report the status of mineral and energy-fuel resources for the Nation or for specific areas.

RESOURCE/RESERVE DEFINITIONS

A dictionary definition of resource, "something in reserve or ready if needed," has been adapted for mineral and energy resources to comprise all materials, including those only surmised to exist, that have present or anticipated future value.

Resource.–A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Original Resource.–The amount of a resource before production.

Identified Resources.–Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. *Identified resources* include economic, marginally economic, and subeconomic components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into *measured, indicated,* and *inferred.*[1]

Demonstrated.–A term for the sum of *measured* plus *indicated.*

Measured.–Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and(or) quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, depth, and mineral content of the resource are well established.

Indicated.–Quantity and grade and(or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume continuity between points of observation.

Inferred.–Estimates are based on an assumed continuity beyond measured and(or) indicated resources, for which there is geologic evidence. *Inferred resources* may or may not be supported by samples or measurements.

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[1] The terms "proved," "probable," and "possible," which are commonly used by industry in economic evaluations of ore or mineral fuels in specific deposits or districts, have been loosely interchanged with the terms measured, indicated, and inferred. The former terms are not a part of this classification system.

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Reserves. – That part of the reserve base which could be economically extracted or produced at the time of determination. The term *reserves* need not signify that extraction facilities are in place and operative. *Reserves* include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

Marginal Reserves. – That part of the reserve base which, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible, given postulated changes in economic or technologic factors.

Economic. – This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Subeconomic Resources. – The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Undiscovered Resources. – Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. *Undiscovered resources* may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or subeconomic. To reflect varying degrees of geologic certainty, undiscovered resources may be divided into two parts:

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Speculative Resources. – Undiscovered resources that may occur either in known types of deposits in favorable geologic settings where mineral discoveries have not been made, or in types of deposits as yet unrecognized for their economic potential. If exploration confirms their existence and reveals enough information about their quantity, grade, and quality, they will be reclassified as identified resources.

Restricted Resources/Reserves. – That part of any resource/reserve category that is restricted from extraction by laws or regulations. For example, *restricted reserves* meet all the requirements of reserves except that they are restricted from extraction by laws or regulations.

GUIDELINES FOR CLASSIFICATION OF MINERAL RESOURCES

1. All naturally occurring metals, nonmetals, and fossil fuels in sufficient concentration can be classified in one or more of the categories.

2. Where the term *reserves* is used alone, without a modifying adjective such as indicated, marginal, or inferred, it is to be considered synonymous with the demonstrated-economic category, as shown in figure 1.

3. Definitions of resource categories can be modified for a particular commodity in order to conform with accepted usage involving special geological and engineering characteristics. Such modified definitions for particular commodities will be given in forthcoming government publications.

4. Quantities, qualities, and grades may be expressed in different terms and units to suit different purposes, but usage must be clearly stated and defined.

5. The geographic area to which any resource/reserve estimate refers must be defined.

6. All estimates must show a date and author.

7. The *reserve base* is an encompassing resource category delineated by physical and chemical criteria. A major purpose for its recognition and appraisal is to aid in long-range public and commercial planning. For most mineral commodities, different grades and tonnages, or other appropriate resource parameters, can be specified

for any given deposit or area, or for the Nation, depending on the specific objectives of the estimators; therefore, the position of the lower boundary of the reserve base, which extends into the subeconomic category, is variable, depending on those objectives. The intention is to define a quantity of in-place material, any part of which may become economic, depending on the extraction plans and economic assumptions finally used. When those criteria are determined, the initial reserve-base estimate will be divided into three component parts: reserves, marginal reserves, and a remnant of subeconomic resources. For the purpose of Federal commodity assessment, criteria for the reserve base will be established for each commodity.

8. *Undiscovered resources* may be divided in accordance with the definitions of *hypothetical* and *speculative resources*, or they may be divided in terms of relative probability of occurrence.

9. *Inferred reserves* and the *inferred reserve base* are postulated extensions of reserves and of the reserve base. They are identified resources quantified with a relatively low degree of certainty. Postulated quantities of resources not based on reserve/reserve-base extensions, but rather on geologic inference alone, should be classified as undiscovered.

10. Locally, limited quantities of materials may be produced, even though economic analysis has indicated that the deposit would be too thin, too low grade, or too deep to be classified as a reserve. This situation might arise when the production facilities are already established or when favorable local circumstances make it possible to produce material that elsewhere could not be extracted profitably. Where such production is taking place, the quantity of in-place material shall be included in the reserve base, and the quantity that is potentially producible shall be included as a reserve. The profitable production of such materials locally, however, should not be used as a rationale in other areas for classifying as reserves, those materials that are similar in thickness, quality, and depth.

11. Resources classified as reserves must be considered economically producible at the time of classification. Conversely, material not currently producible at a profit cannot be classified as reserves. There are situations, however, in which mining plans are being made, lands are being acquired, or mines and plants are being constructed to produce materials that do not meet economic criteria for reserve classification under current costs and prices, but would do so under reasonable future expectations. For some other materials, economic producibility is uncertain only for lack of detailed engineering assessment. The marginal-reserves category applies to both situations. When economic production appears certain for all or some of a marginal reserve, it will be reclassified as reserves.

12. Materials that are too low grade or for other reasons are not considered potentially economic, in the same sense as the defined resource, may be recognized and their magnitude estimated, but they are not classified as resources. A separate category, labeled *other occurrences*, is included in figures 1 and 2.

13. In figure 1, the boundary between *subeconomic* and *other occurrences* is limited by the concept of *current or potential feasibility of economic production*, which is required by the definition of a resource. The boundary is obviously uncertain, but limits may be specified in terms of grade, quality, thickness, depth, percent extractable, or other economic-feasibility variables.

14. Varieties of mineral or energy commodities, such as bituminous coal as distinct from lignite, may be separately quantified when they have different characteristics or uses.

15. The amount of past cumulative production is not, by definition, a part of the resource. Nevertheless, a knowledge of what has been produced is important to an understanding of current resources, in terms of both the amount of past production and the amount of residual or remaining in-place resource. A separate space for cumulative production is shown in figure 1. Residual material left in the ground during current or future extraction should be recorded in the resource category appropriate to its economic-recovery potential.

16. In classifying reserves and resources, it is necessary to recognize that some minerals derive their economic viability from their coproduct or byproduct relationships with other minerals. Such relationships must be clearly explained in footnotes or in an accompanying text.

17. Considerations other than economic and geologic, including legal, regulatory, environmental, and political, may restrict or prohibit the use of all or part of a deposit. Reserve and resource quantities known to be restricted should be recorded in the appropriate classification category; the quantity restricted and the reason for the restriction should be noted.

18. The classification system includes more divisions than will commonly be reported or for which data are available. Where appropriate, divisions may be aggregated or omitted.

19. The data upon which resource estimates are based and the methods by which they are derived are to be documented and preserved.

RESOURCES OF (commodity name)

[A part of reserves or any resource category may be restricted from extraction by laws or regulations (see text)]

AREA: (mine, district, field, State, etc.) UNITS: (tons, barrels, ounces, etc.)

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Other Occurrences	Includes nonconventional and low-grade materials

Author: Date:

FIGURE 1. – Major elements of mineral-resource classification, excluding *reserve base* and *inferred reserve base.*

RESOURCES OF (commodity name)

[A part of reserves or any resource category may be restricted from extraction by laws or regulations (see text)]

AREA: (mine, district, field, State, etc.) UNITS: (tons, barrels, ounces, etc.)

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserve Base		Inferred Reserve Base		
MARGINALLY ECONOMIC					
SUB-ECONOMIC					

Other Occurrences	Includes nonconventional and low-grade materials

Author: Date:

FIGURE 2. – *Reserve base* and *inferred reserve base* classification categories.

UNITS OF MEASURE

1 carat (diamond) = 200 milligrams
1 flask (fl) = 76 pounds, avoirdupois
1 karat (gold) = one twenty-fourth part
1 kilogram (kg) = 2.2046 pounds, avoirdupois
1 long ton (lt) = 2,240 pounds, avoirdupois
1 long ton unit (ltu) = 1% of 1 long ton or 22.4 pounds, avoirdupois
long calcined ton (lct) - excludes water of hydration
long dry ton (ldt) - excludes excess free moisture
Mcf = 1,000 cubic feet
1 metric ton (mt) = 2,204.6 pounds, avoirdupois or 1,000 kilograms
1 pound (lb) = 453.6 grams
1 short ton (st) = 2,000 pounds, avoirdupois
1 short ton unit (stu) = 1% of 1 short ton or 20 pounds, avoirdupois
1 troy ounce (tr oz) = 1.09714 avoirdupois ounces

COUNTRY GROUPINGS

Centrally planned economy countries - Comprised of the following:

Albania
Bulgaria
China
Cuba
Czechoslovakia
German Democratic Republic
Hungary
Kampuchea
Korea, North
Laos
Mongolia
Poland
Romania
U.S.S.R.
Vietnam

TARIFF RATES

The countries or areas for which non-most-favored-nation (Non-MFN) rates apply are the following:

Albania
Bulgaria
Cuba
Czechoslovakia
Estonia
German Democratic Republic and East Berlin
Indochina (any part of Cambodia, Laos, or Vietnam which may be under Communist domination or control)
Korea (any part which may be under Communist domination or control)
Kurile Islands
Latvia
Lithuania
Outer Mongolia
Poland
Southern Sakhalin
Tanna Tuva
Union of Soviet Socialist Republics and the area in East Prussia under the provisional administration of the Union of Soviet Socialist Republics

Under the Generalized System of Preferences, special tariff rates were designated for Israel, Caribbean Basin Countries, and Least Developed Developing Countries. A detailed listing of these rates appears in the Federal Register, Vol. 50, No. 172, Sept. 5, 1985, pp. 36220-36403.

OTHER PUBLICATIONS

Additional statistical, economic, and technologic data on mineral commodities are available in other publications of the Bureau of Mines and the Geological Survey.

Bureau of Mines

Minerals Yearbook - An annual publication which reviews the mineral industry of the United States and foreign countries. Contains statistical data on metals and minerals, and their products and includes information on economic and technical trends and developments. The Yearbook is published in three volumes: Volume I, Metals and Minerals; Volume II, Area Reports, Domestic; and Volume III, Area Reports, International.

Mineral Industry Surveys - Periodic statistical and economic reports designed to provide timely statistical data on production, distribution, stocks, and consumption of significant mineral commodities. The surveys are issued monthly, quarterly, or at other regular intervals, depending on the need for current data.

Perspectives - Reports which present timely data on mineral developments in foreign geographic areas.

Mineral Commodity Profiles - Periodic reports covering a single important mineral commodity and containing both current statistical data and text covering strategic uses and industry problems.

Bulletins - Reports which describe major Bureau investigations or studies that are considered to have permanent value.

Information Circulars - Reports which primarily compile, review, abstract, and discuss various activities and developments in the mineral industries

Reports of Investigations - Describe the principal features and results of minor investigations or phases of major investigations, to keep the mineral industries and the public informed on progress in original Bureau research.

These and other Bureau reports are described in the monthly release "New Publications--Bureau of Mines," which is available free upon request from the Branch of Editorial Services, Bureau of Mines, 4900 LaSalle Road, Avondale, Md. 20782.

Geological Survey

Professional Papers - Comprehensive reports on the results of resource studies and of topographic, hydrologic, paleontologic, and geologic investigations, including longer contributions to the literature on scientific and engineering subjects.

Bulletins - Either final or progress reports on the results of resource studies and of topographic and geologic investigations; shorter contributions to economic and general geology; and descriptions of Survey instruments and techniques.

Circulars - Timely scientifically sound and accurate reports for which a simpler and less permanent format is deemed adequate. In general, the treatment of the subject is less comprehensive and final, or the report is of relative local or restricted interest, or of relatively temporary usefulness.

Maps and Charts - Numerous maps and charts pertaining to mineral resource investigations are published These include: Mineral Investigations Field Studies Maps: and Mineral Investigations Resource Maps.

These Geological Survey publications are described in the monthly release "New Publications of the Geological Survey," which is available free upon request from the U.S. Geological Survey," 582 National Center, Reston, VA 22092.

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MARCH 3, 1849

Created in 1849, the Department of the Interior—America's Department of Natural Resources—is concerned with the management, conservation, and development of the Nation's water, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that parks and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States—now and in the future.

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